THE PLANT DISEASE REPORTER

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PLANT DISEASE EPIDEMICS
and
IDENTIFICATION SECTION

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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Plant Disease Epidemics and Identification Section serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

THE PLANT DISEASE REPORTER

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PLANT DISEASE EPIDEMICS AND IDENTIFICATION SECTION

Horticultural Crops Research Branch — Plant Industry Station, Beltsville, Maryland
Volume 41 — March 15, 1957 — Number 3

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STRIGA REPORTED IN SOUTH CAROLINA[1]

Quintin L. Holdeman

The occurrence of a parasitic weed new to the western hemisphere has been reported recently in North Carolina[2]. Since this weed is potentially a threat to other areas, the purpose of this report is to record its occurrence in South Carolina, its identification, and the date of earliest observation. Additional pictures and information are presented as an aid to identification by agricultural workers.

Material submitted to Dr. S. F. Blake, Plant Industry Station, Beltsville, Maryland, was identified as Striga asiatica (L.) O. Kuntze[3].

As observed in South Carolina, Striga plants varied in height from 2 to 15 inches. Plants were frequently branched, branches growing erect. Color of foliage and stems varied from dark green to "nigrogen-deficient" green. Leaves were linear, tapering to a point and curving downward. Occasionally, lower leaves were in opposite pairs; commonly, the leaves were alternate, on a square stem. Individual leaves tended to die as the sessile seed capsules in their axils turned dark on maturity. In contrast, the stems remained green until the death of the entire plant. The flower was tubular, with a well-developed two-lipped corolla measuring 5 to 11 mm in diameter. The corolla was cardinal red on the upper surface, with a straw-yellow eye. On the lower surface, the corolla and tube were straw-yellow with a pink tinge frequently showing through from the upper surface. Seeds were numerous, minute, and brown, measuring less than 1/4 mm in length and readily passing through a standard 40-mesh sieve.

FIGURE 1. Flowers of Striga. The upper surface of the petals is orange red or cardinal red, the lower surface straw yellow. Approximately 1 1/2 times natural size.

Although the weed has been observed in tobacco and cotton fields where crabgrass was growing, damage to corn and crabgrass only has been associated with the weed. The abundance of Striga plants in the field was not always correlated with the extent of damage to corn.

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[1] Technical Contribution 264 from the South Carolina Agricultural Experiment Station, Clemson, South Carolina.

[2] Garriss, H. R., and J. C. Wells. 1956. Parasitic herbaceous annual associated with corn disease in North Carolina. Plant Dis. Reptr. 40: 837-839.

[3] [Ed. NOTE: Further study has shown that the species is not asiatica. Investigation to determine its identity is being continued.]

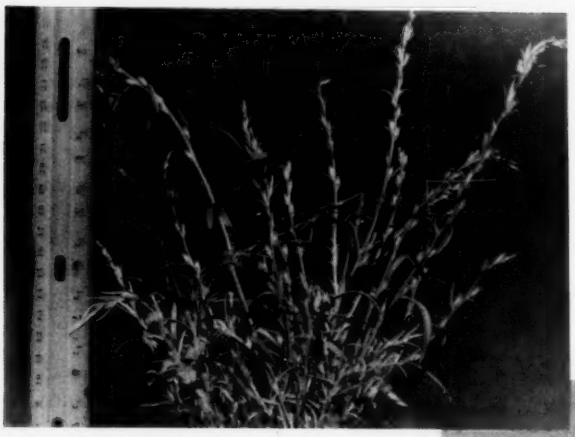

FIGURE 2. Striga plants showing details of stem and seed pods. Approximately 3/10 natural size.

FIGURE 3. Damaged corn field, Dillon County, South Carolina. Photograph taken August 1956. County Agent holding healthy stalk from non-infested area.

Striga was first observed on the farm of Roser Strouo in Horry County, 5 miles south-southeast of Nichols, South Carolina, on August 29, 1951, associated with stunting of corn. Because of the resemblance of the stunting to nematode injury, the very high population of the meadow nematode Pratylenchus zeae Graham, and the severity of the stunting in the presence of only an occasional Striga plant, the cause was not properly diagnosed. Attempts to identify the weed in the laboratory were unsuccessful. Striga was next encountered in August, 1956, when the author checked a Dillon County corn field that had yielded an extremely high population of meadow nematodes.

The origin of the original infestation will be difficult to determine. In 1951, the farmer pointed out the association of the weed-infested area with a power line pole and stated that the weed had not appeared until after the construction of the power line. The contractor building the line was known to have brought equipment from Georgia and to have been working both sides of the North Carolina-South Carolina State line in the general area where Striga has been found. The introduction of Striga seed on digging equipment is not beyond the realm of possibility although, so far as is known, Striga does not occur in Georgia.

It is yet to be determined if this species of Striga is a serious threat to corn on soils other than the poor sandy type on which it has been found to date, or if it offers a threat to the corn belt or to our grass lands. Where it occurs in South Carolina, it has drastically reduced corn yields and in some cases destroyed crabgrass.

CLEMSON COLLEGE PEE DEE EXPERIMENT STATION, FLORENCE, SOUTH CAROLINA

ARTIFICIAL FIELD INOCULATION OF POTATOES WITH ALTERNARIA SOLANI[1]

Norman R. Gerhold[2]

Owing to the dry weather which often prevails in Colorado, it is difficult to evaluate certain spray materials for the control of early blight of potatoes incited by the organism Alternaria solani. A successful field inoculation would result in more uniform infection and thus provide more suitable conditions for the evaluation of fungicides. During the summer of 1955, a test was initiated to determine whether Bliss Triumph potato plants could be successfully inoculated in the field with the use of an overhead sprinkling system.

Experimentation and Results

Alternaria solani was grown on potato-dextrose agar plates and incubated at room temperature. After a 2-week growing period the contents of 25 plates were ground in a Waring Blendor with tap water and filtered through cheesecloth. The spore and mycelial suspension was added to approximately 4 gallons of water in a carboy. The content of the carboy was then introduced into the sprinkling system by the device pictured in Figure 1.

FIGURE 1. A device for the artificial inoculation of field plots through an overhead sprinkling system: A -- Carboy. B -- In-the-line valve. C -- Main suction line.

[1] Published as Scientific Series Paper No. 499, with the approval of the Director of Colorado Agricultural Experiment Station.

[2] Associate Plant Pathologist, Botany and Plant Pathology Section, Colorado A & M College, Fort Collins, Colorado.

Table 1. Effectiveness of certain fungicides for control of potato early blight (Alternaria solani).

Treatment	Rate of application pounds per 100 gal.	Percent disease at harvest time
Zineb	3	5.4
Maneb	3	20.0
Captan	3	58.0
Check	-	91.0
Check	-	88.0

Copper tubing, with an in-the-line valve, was placed on the main suction line leading from three irrigation wells. By regulating the valve it was possible to govern the amount of inoculum introduced into the sprinkling system. From the carboy the inoculum was drawn by suction through the pump into a 4-inch line. A 3-inch lateral line was placed in the center of the potato plot. At 20-foot intervals, Rain Bird sprinkler heads with 3-foot risers were inserted into the lateral line. With 45 pounds of nozzle pressure, each sprinkler head covered an area approximately 90 feet in diameter.

Prior to inoculation the sprinkler system was operated for approximately 30 minutes in order to wet the ground and foliage thoroughly. The in-the-line valve leading from the carboy was regulated to apply 4 gallons of spore and mycelial suspension in 20 minutes. A randomized spray plot was inoculated by this method three times during the growing season. Each randomized block consisted of 10 rows 40 feet in length and was replicated 3 times. Prior to each inoculation period, glass slides covered with vaseline were placed at random in the potato plot for observation purposes.

Three fungicidal sprays were evaluated for their effectiveness in controlling the organism responsible for early blight. Six applications were applied at 7- to 10-day intervals. Disease readings based on the Weber-Fechner law, as described by Horsfall[3], were made just prior to harvest. The disease readings and the rates of application are presented in Table 1.

Conclusions

As shown in Table 1, potato plants were successfully inoculated with Alternaria solani by introducing the inoculum into the overhead sprinkling system. In the two non-sprayed inoculated checks, disease readings of 88 and 91 percent were recorded.

Zineb applied at a rate of 3 pounds per 100 gallons of water gave satisfactory control under these severe experimental field conditions.

BOTANY AND PLANT PATHOLOGY SECTION, COLORADO AGRICULTURAL EXPERIMENT STATION, FORT COLLINS, COLORADO

[3] Horsfall, J. G. 1945. Fungicides and their action. Waltham, Massachusetts: Chronica Botanica Company.

SEED TRANSMISSION, OVERWINTERING, AND HOST RANGE OF THE CUCURBIT-ANGULAR-LEAF-SPOT PATHOGEN

Seymour D. Van Gundy and J. C. Walker

Summary

Pseudomonas lachrymans was shown to occur on cucumber seed grown in California and Oregon. The organism persisted in infested soil and/or infested plant debris throughout one Wisconsin winter. During the growing season soil became infested in the vicinity of infected vines and served as a source of current-season as well as overwintering inoculum. *P. lachrymans* infected all species of the cucurbits tested but symptoms were most severe in field and greenhouse on cucumber and *Cucumis anguria*.

At the present time most of the seed of cucumber (*Cucumis sativus* L.) used in Wisconsin is grown in the inland valleys of California and Oregon. Since it has been observed repeatedly that angular leaf spot occurs in Wisconsin, often in epidemic proportions, in fields where cucumbers had not been grown previously and in which California- or Oregon-grown seed was used, it was important to know whether seed from these areas was generally free from the angular leaf spot organism, *Pseudomonas lachrymans* (E. F. Sm. & Bryan) Carsner. It has been implied but not proved that the organism lives over between crop seasons in soil and/or infested plant debris. There has been no comprehensive study of the host range of the organism reported.

SEED TRANSMISSION STUDIES

Wiles and Walker (5) demonstrated the bacteria in the placental tissue of cucumber fruit and in the funiculus of the seed. On the basis of circumstantial evidence from a study of germinating seeds, they believed that internal invasion of the seeds occurred.

In 1953 and 1954, 13 commercial lots of seed grown in California or in Oregon were tested for the presence of the organism. Each sampling consisted of approximately 500 seeds which were planted in sterilized 12-inch clay dishes containing sterilized vermiculite. Cotyledonary lesions were evident after 7 to 10 days. The suspected cotyledons were collected and macerated in a sterilized mortar and pestle and 20 ml of extract was used to inoculate healthy cucumber plants. The presence of the organism was determined also by culturing on agar from cotyledons and subsequently inoculating healthy plants. Several of the lots were assayed two or more times. Of the 13 lots tested, 10 were shown to carry the organism. However, there was not a close correlation between the presence of cotyledonary lesions and positive infection with cotyledonary extract. This may mean that all the cotyledonary lesions were not initiated by the angular leaf spot organism or that in a considerable number of cases the viable organism died during storage.

VIABILITY OF PATHOGEN IN SOIL AND IN HOST TISSUE

Gorlenko and Vorenkevich (3) claimed that the pathogen overwintered only in well-preserved diseased leaves left on the surface of the soil. Our field observations indicated that there was a build-up and carry-over of the organism in the soil from one season to another.

Soil samples were collected from several fields during the summer of 1953 and placed in clay pots buried to soil level in open cold-frames. Similar pots contained infected leaf and fruit tissue under 1 to 2 inches of soil. Another collection of infected leaves was suspended in a wire cage in a cold-frame over a pot of non-infested soil. All of these samples were exposed to the winter weather of 1953-1954. Testing for the organism was carried out periodically by agitating samples of soil or plant debris in water which was atomized immediately on healthy cucumber plants. Further identification was made by culturing on agar and inoculation of healthy plants.

The pathogen was demonstrated consistently six times in the soil samples from August 1953 through May 1954 but not after the latter date. The organism was shown to be viable in the pots containing soil, rotted leaves and rotted fruit through June 1954. Isolations from the suspended leaf tissue and from the soil beneath were likewise successful through June 1954.

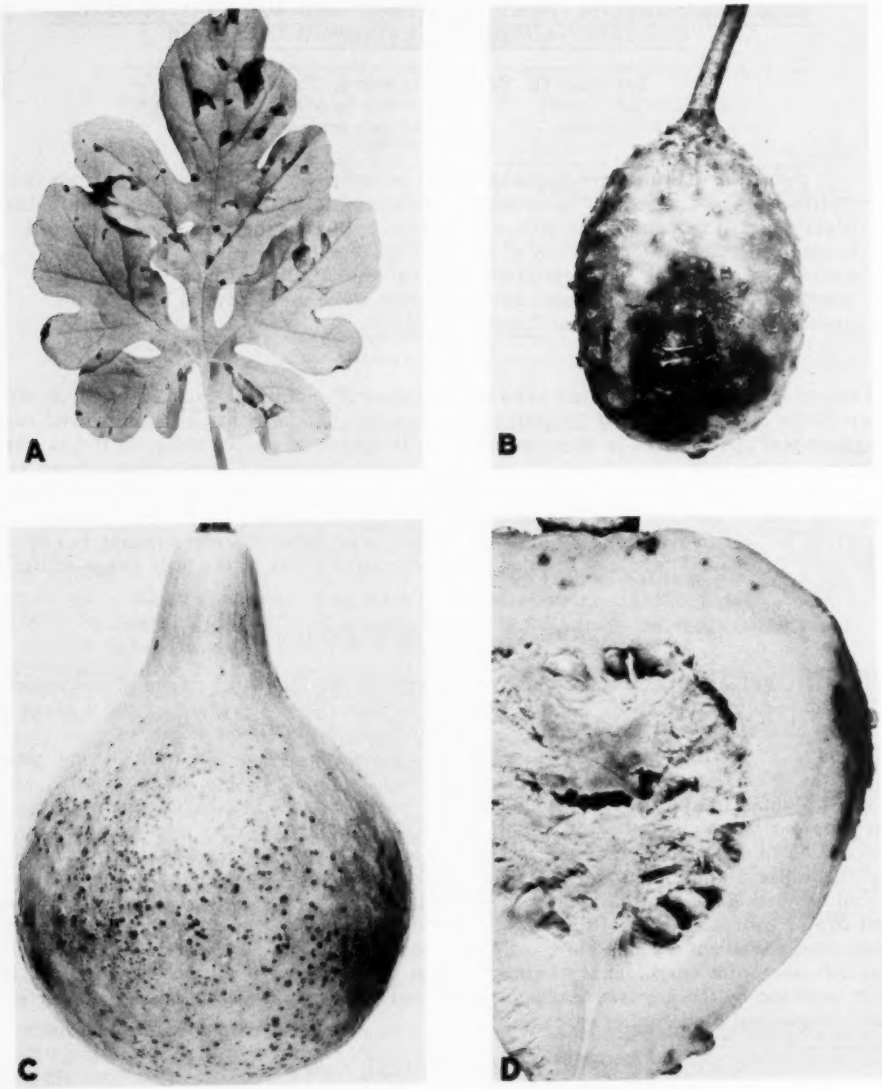

FIGURE 1. Angular leaf spot lesions on A, watermelon; B, West Indian gherkin; C, Lagenaria gourd; D, Golden Hubbard squash.

Following these experiments soil samples were taken from beneath infected vines in the field during the summer of 1954 and were assayed for the presence of the organism. In more than a dozen such tests the soil was always found to be infested.

To determine how long the organism remained viable in dry plant tissue, four samples of infected leaf tissue were collected, cut in fine strips, desiccated, and stored over calcium chloride at 4° C. They were assayed every 6 months by macerating the dried tissue in 10 ml of distilled water and atomizing on healthy cucumber plants. Viable organisms were demonstrated from September 1953 through February 1956, a period of 2-1/2 years. This method may provide an excellent method of keeping pathogenic bacterial cultures for long per-periods without transfer.

HOST RANGE STUDIES

Carsner (2) reported a limited study of the host range of Pseudomonas lachrymans. He found the following cucurbits susceptible under field conditions: Bryanopsis laciniosa Naud., Cucumis anguria L., C. dipsaceus Ehrenb., C. sativus L., Lagenaria siceraria (Molina) Standl., and Luffa cylindrica (L.) M. Roem. Those not infected were Citrullus vulgaris Schad., Cucumis melo L., Cucurbita maxima Duch., C. moschata Duch., C. pepo L., Echinocystis lobata (Michx.) T. & G., Trichosanthes sp., and Momordica sp. Smith (4) later reported the pathogen on honeydew melons grown under irrigated conditions in Arizona and Colorado. Ark (1) reported isolating the organism from field-grown Zucchini squash (Cucurbita pepo) in California.

The representatives of the Cucurbitaceae tested in the present study included from three to five varieties each of the commercial cucurbits and various ornamental cucurbits available. All the representatives were tested at least three times in the greenhouse with two different isolates of the organism. Some were tested in the field where the humidity was enhanced by means of overhead irrigation applied 2 to 3 hours per day, twice each week.

The following members of the Cucurbitaceae were susceptible when inoculated in the greenhouse by atomizing with a suspension of the organism and placing in the moisture chamber for 48 hours: Citrullus vulgaris, Cucumis anguria, C. dipsaceus, C. ficifolia Bouche, C. melo, C. prophetarum L., C. sativus, Cucurbita maxima, C. moschata, C. okeechobeensis Bailey, C. pepo, Lagenaria siceraria Rusby, Luffa cylindrica L., Melothria pendula L., Mormordica balsamia L., M. charantia L., and Sicana odifera Naud.

In the field, foliage and placental-type fruit lesions were observed on Cucumis anguria, C. melo, and C. sativus. Foliage and surface-type fruit lesions were observed on Cucurbita maxima, C. moschata, C. pepo, and Lagenaria siceraria. There were lesions on the foliage of Citrullus vulgaris (Fig. 1) but none on the fruit.

Foliage and fruit symptoms respectively, were most severe on West Indian gherkin, Cucumis anguria (Fig. 1), and cucumber, C. sativus. Of 23 varieties of cucumber tested, including PI 173892 listed by the Plant Introduction Section, United States Department of Agriculture, as somewhat tolerant, all were very susceptible. Young fruits 7/8 to 1-1/2 inches in diameter were most susceptible in the field and in the greenhouse. The general freedom from symptoms of fruits picked in the immature stage for processing was due primarily to the rapid growth of young fruits and corresponding reduction in time available for symptoms to develop, rather than to any inherent lack of susceptiblity of young fruits. Likewise, placental infections of mature fruits were the result of infections on young fruits. The period required for development of signs of placental infection on fruits was 3 to 4 weeks.

The foliage of the varieties of Cucurbita maxima and C. moschata was nearly as susceptible as cucumber in the greenhouse tests, but in the field leaf symptoms were less conspicuous and dissemination was limited probably because of the heavy foliage which reduced movement of infested soil particles by wind action. The small fruits were quite susceptible and if severely infected they shriveled and dropped off. Penetration of older fruits was slow and the depth of the lesion seldom exceeded 3/4 inch (Fig. 1). The warty appearance of the fruit was not necessarily indicative of angular leaf spot since wounding by other agents causes similar excrescences.

The varieties of Cucumis melo and Cucurbita pepo tested were less seriously affected than cucumber. Lesions on the leaves were circular with a small bright chlorotic halo and were smaller than those on cucumber. On the fruits of Cucurbita pepo and Lagenaria siceraria (Fig. 1), small water-soaked pimples were delimited by the tough subepidermal layers of the fruit. Although one fruit of Cucumis melo was observed with placental infection,

infected fruits were usually destroyed by secondary organisms before maturity. The ornamental cucurbits were mildly affected and symptoms were similar to those on Cucumis melo and Cucurbita pepo.

A few species outside the Cucurbitaceae were inoculated in the greenhouse with three isolates of Pseudomonas lachrymans. The species included were Phaseolus vulgaris L., P. lunatus L., Pisum sativum L., Trifolium pratense L., Nicotiana glutinosa L., and Lycopersicum esculentum Mill. Of these, only P. lunatus showed indications of infection. Small, black necrotic lesions appeared which did not enlarge although the organism was easily isolated from them. It has not been determined whether P. lunatus becomes infected in nature.

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A LOCALIZED OCCURRENCE OF CUCUMBER MOSAIC VIRUS IN GLADIOLUS

Frank P. McWhorter[1]

A white break of gladiolus that in Oregon is regularly caused by strains of cucumber mosaic virus (CMV) has been present in the Portland area for several years. Before 1952, occasional stocks of some varieties had 50 percent or more plants infected, but average stocks had less than 2 percent infected. The disease is easily noted in colored varieties because of contrasty white blotching of flowers accompanied by crinkling, shrinking, and other flower deformations, and because of chlorotic streaking and blotching of the foliage; in varieties with white or yellow flowers the foliar symptoms and obvious flower injuries usually facilitate diagnosis. These conspicuous symptoms enabled the Oregon State Nursery Service, with the cooperation of the growers, to effect control of the disease in the fields. Stocks having high percentages of the plants infected were destroyed and stocks with low percentages were rogued, and generous spraying for aphids was encouraged. By 1955, the disease had practically disappeared from the hundreds of acres of gladiolus grown in the Portland area. This article reports a recurrence during 1956 that is unique in the history of our gladiolus industry.

This recurrence involved one grower who planted gladiolus in large and small fields about 2 1/2 miles apart. He used his own stocks and the same varieties in all the plantings, thus eliminating the explanation that variations in disease incidence in fields and parts of fields could be attributed to differences in stocks. For clarity, the fields are discussed separately and then compared to show what circumstances may have related to the invasion of parts of each field by cucumber mosaic virus.

The larger field, comprising 17 acres for commercial production of corms, was planted April 15 to 25 with the same varieties used in the small field described later. The field remained free from white break, except for about 1/4 acre in the northwest corner planted to Picardy and Spot Light. Some white break developed there and the area had to be rogued twice. According to the grower the incidence of infection was about 5 percent. The infected area was bounded by a planting of Youngberries.

The small field was divided into two sections separated by only a field road and planted at different times. One section of about 3 acres, the part that remained healthy, was planted April 13 to 25 with cormels. The adjoining section, about 3 1/2 acres, was planted June 10 to 29 with corms for flower production. Most varieties in the section for flower production developed the unbelievable incidence of more than 98 percent of the plants showing conspicuous white break symptoms. The infection was so complete and destructive that the grower harvested only a few dozen flowers from the entire 3 1/2 acres. The disease, except for varietal variations, was distributed evenly throughout the entire block. The same varieties grown from cormels and small corms planted during April and separated from the June planting by only a field road had normal foliage; some of these small plants bloomed and had normal flowers. Only by indexing can the apparent freedom from cucumber mosaic virus be proved for these small plants, but there is no doubt that adjoining large plants were infected to a degree we have never seen or heard of before in the Pacific Northwest.

No satisfactory explanation for this occurrence was apparent. Several local records on green-aphid migrations to gladiolus indicate that they are likely to take place when the plants are in the "dagger" stage. Only when the plants are in that stage do various species of green aphids linger long enough and increase in numbers sufficiently to make them noticeable as pests. This circumstance, coupled with the time of planting, must be related to the unbelievable degree of infection in this one field, but the grower, who was watching for aphids, did not notice any and did not spray. The extremely high incidence of the disease, the fact that no aphid infestation compatible with general inter-plant spread was apparent in the field, and the even distribution of infection throughout the field indicate that a large accessible reservoir of cucumber mosaic virus was present in the immediate area. However, there were no cucurbit crops in the area while the gladiolus plants were being grown.

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[1] Pathologist, Oregon Agricultural Experiment Station, Corvallis, and Agent, Horticultural Crops Research Branch, Agricultural Research Service, United States Department of Agriculture.

The areas bounding the mildly affected corner of the large field and the severely attacked small field have been surveyed to find a plausible source for the virus. The invaded area of the large field was the northwest corner, which is bounded by Youngberry vines and a small amount of escaped grasses and clovers. The large field was certainly infected by vectors moving in from the northwest, which indicates that the vectors were carried in by the prevailing winds. The June-planted section of the small field, which was close to 100 percent infected, was so evenly infected that the path of the vectors could not be ascertained but here also the direction of prevailing winds indicated that the movement was probably from the northwest, over grass and clover sod. The leeward side of the field was bounded by patches of red clover, emerging potatoes, and grass and clover sod at the time that infection probably occurred.

We have experimentally transferred strains of cucumber mosaic virus (CMV) isolated from cucumbers in the Portland area to sub clover, but not to red clover. Both clovers and grasses should be investigated thoroughly as potential hosts of CMV in an attempt to explain such outbreaks as this one in which, apparently, none of the generally accepted hosts was involved.

Although specific data on the variations of symptoms in current varieties of gladiolus are of little permanent value because of continual changes in varieties grown commercially the following observations on some of the varieties studied may be of general interest.

Ninety-eight to 100 percent of the individual plants in the following varieties had unmistakable symptoms of white break: Sherwood, a purple; Pastel, a smoky; Modern Times, a wine-rose; Kathy Lee, a lemon yellow; Spic and Span, a pink; Salman's Glory, a creamy white; White Goddess, a white; Tivoli, a pink; and Huntress, a lavendar. Pastel, Kathy Lee, Salman's Glory, and Tivoli had both severe flower and severe foliage symptoms; the others showed principally flower symptoms.

Flower breaking was noticeable either as a contrasty color rearrangement or as a flower distortion. The varieties Huntress, Modern Times, and Pastel showed the distortion and shrinking characteristic of white break as described in plantings in the East.

The variety Snow Princess, a white, bore almost normal flowers, but its foliage was strongly streaked.

Only 50 percent of the plants of variety Abu Hassen, a deep violet, were visibly infected. In contrast to Snow Princess, Abu Hassen flowers were strongly broken, but the foliage appeared normal.

No symptoms were apparent in the variety Leading Lady, a creamy white. Since we were asked to investigate this outbreak at a time when neither test plants nor time was available for a proper analysis and the grower had already destroyed the infected planting, it was not possible to make an adequate virus analysis. Thus it is not known whether the Leading Lady plants (a very small part of the planting) were infected and symptomless or were actually resistant to the virus. Salman's Glory variety with typical symptoms was tested for CMV on cucumber and tobacco and CMV was isolated. The adjoining healthy planting of the same varieties will be indexed, however, to determine whether the plants actually escaped the virus and to protect the grower, who will not sell them if they are infected.

This invasion of a gladiolus field by cucumber mosaic virus constitutes a natural experiment towards interpreting white break as a disease of dubious etiology and white break as certainly due to CMV. Several years of isolation tests by investigators here, including Dr. Gordon Snow, have shown extreme variability in CMV strains from affected gladiolus. The strains vary greatly in ease of isolation, and often, especially in cases where only flowers develop specific symptoms, can be isolated only from flowers. The virus changes the gladiolus and the gladiolus changes the virus.

OREGON AGRICULTURAL EXPERIMENT STATION, AND UNITED STATES DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, COOPERATING, CORVALLIS, OREGON

VIRUS DISEASES OF PEPPERS IN CENTRAL FLORIDA SURVEY RESULTS 1955

C. W. Anderson and M. K. Corbett[1]

Summary

The five basic indicator plants selected for use in the survey were Datura stramonium, Nicotiana glutinosa, N. tabacum vars. Turkish or White Burley, and Capsicum frutescens vars. California Wonder and Tabasco. Plants of Zinnia elegans, Capsicum frutescens var. Large Bell Hot, Vigna sinensis vars. Blackeye and Sill and Walker, and Cassia tora were used as secondary indicators. To counteract the inhibitory effect of pepper sap, all inoculum from peppers was diluted 1/50 with distilled water.

Tobacco etch virus was the cause of the most common viral disease of peppers in seven counties of central Florida in the spring of 1955. The tobacco mosaic, potato Y, cucumber mosaic, and aster ringspot viruses were found in approximately equal numbers of the fields examined. Aster ringspot virus was found only in Seminole and Volusia Counties, while cucumber mosaic virus appeared most often in Seminole and Hardee Counties. The most serious pod disorder was the severe form of "yellow-pod" disease, a trouble induced by simultaneous infection by the etch and tobacco mosaic viruses.

Evidence obtained indicates that severe damage and extensive infection caused by several viruses was associated with proximity of the pepper plantings to certain important weed hosts. Among the hosts mentioned in this report are: Solanum nigrum and S. gracile (etch and Y viruses); Physalis angulata (etch and Y viruses); P. elliottii (tobacco mosaic virus); and Vinca rosea, Vigna sinensis, and Commelina nudiflora (cucumber mosaic virus). Mosaic disease is common on plants of certain weed species in central Florida. Some of the species are known sources of cucumber mosaic virus. Yet within central Florida, these diseases are more widespread than cucumber mosaic virus. Other viruses probably account for most of the mosaic disease noted on the weeds in question.

Field grown pepper (Capsicum frutescens L.) plants are subject to infection by at least seven viruses, including those of tobacco mosaic, tobacco etch, cucumber mosaic, potato Y, aster ringspot, alfalfa mosaic, and tomato spotted wilt.

Doolittle (5), Wellman (11, 12, 13), and others studied the sources of cucumber mosaic virus in Florida. To date, this is the only virus known to infect celery in Seminole County, Florida; and Wellman (11) found that the virus spread with particular rapidity in fields of pepper and squash.

Simons (9) discovered that plants of Solanum gracile Link. are important sources of potato virus Y in south Florida. Later, Simons et al., (10) found this virus destructive in several southern Florida areas in which potatoes are now or were formerly grown.

The present study was undertaken in central Florida in order to determine the geographical distribution of the viruses attacking pepper; their relative prevalence; their economic importance; and their seasonal occurrence. Only a part of the information obtained on virus sources will be reported here.

MATERIALS AND METHODS

From the literature and from greenhouse tests with one or more strains of tobacco mosaic virus (Marmor tabaci Holmes) (TMV), tobacco etch virus (M. erodens Holmes) (TEV), potato

[1] Florida Agricultural Experiment Station, Journal Series, No. 592. The writers are indebted to E. West for identifying the various plant species.

virus Y (M. upsilon Holmes) (PVY), cucumber mosaic virus (M. cucumeris Holmes) (CMV), alfalfa mosaic virus (M. medicaginis Holmes), potato virus X (Annulus dubius Holmes), and aster ringspot virus (A. wellmanii Anderson) (ARSV), on many plants, the following list of virus indicator plants was chosen. The basic indicators were plants of Capsicum frutescens vars. California Wonder and Tabasco, Nicotiana glutinosa L., N. tabacum L. vars. Turkish or White Burley, and Datura stramonium L. Other plants used as indicators or for immunological studies were Capsicum frutescens var. Large Bell Hot, Zinnia elegans Jacq., Vigna sinensis (Torner) Savi vars. Blackeye and Sill and Walker, and Cassia tora L.

Pepper foliage samples were collected under aseptic conditions and brought to the laboratory in polyethylene bags or in water-filled, bagged test tubes. All expressed pepper sap was diluted 1/50 with distilled water in order to overcome the inhibitory action of pepper sap. Weed samples were handled as above, except that both diluted and undiluted inoculum was used. The carborundum method of mechanical inoculation was used exclusively.

No isolate was identified until it had been inoculated into plants of all five basic indicators. Subinoculations were made as needed. All inoculated plants were kept at least 15 days unless clear symptoms became evident earlier.

RESULTS

Table 1 lists the number of fields in which specific viruses were found and the number of virus-free fields observed, by counties.

Table 1. The geographic distribution of pepper viruses in seven counties.

County	Numbers of pepper fields infected with						Total number of fields examined
	TEV[a]	TMV	PVY	ARSV	CMV	No virus	
Alachua	5	7	2	0	1	11	23
Sumter	1	0	2	0	1	2	5
Volusia	2	1	0	2	0	0	2
Seminole	2	1	1	6	3	1	10
Hillsborough	4	1	0	0	1	2	7
Manatee	0	0	2	0	0	1	3
Hardee	1	0	3	0	2	4	7
Totals	15	10	10	8	8	21	57

[a] The virus symbols are explained under "Materials and Methods".

Pepper viruses were present in 36 of the 57 fields examined; but the percentage of plants infected was low in many cases.

Tobacco Etch Virus: -- This virus was found in more fields than any other single virus. It was identified primarily by means of the wilt reaction of Tabasco pepper plants (6) and the mottle reaction of Datura plants. The initial reaction of one etch isolate was primarily that of TMV. Etch was freed from this complex by passage through plants of Cassia to plants of Tabasco pepper and Datura. In a similar case, the original concentration of TMV was evidently low and TEV was separated from the complex by passage through Nicotiana glutinosa plants.

Most of the 19 TEV isolates obtained from pepper plants in 15 fields were secured from plants displaying a disease described as "vein banding crinkle". One TEV isolate was obtained from a plant of Solanum nigrum L.

Pepper fields evidently remained free of etch virus until late May in most areas. However, the virus was present earlier in Hillsborough County, particularly.

Tobacco Mosaic Virus:--Local lesions on plants of Tabasco pepper, Datura, and Nicotiana glutinosa furnished the primary means of identifying this virus. Twelve isolates were obtained from pepper plants in nine fields. A mottled plant of Physalis elliottii Kunze yielded this virus in a tenth field.

Pepper plants from which this virus was obtained exhibited various symptoms of infection. Some plants displayed a "ring mottle", while others displayed the more typical mottle associated with TMV infections. Several plants showed the "yellow-pod" fruit symptom but very little leaf mottle. One plant which exhibited a severe form of the "yellow-pod" disease and severe leaf mottle also yielded TEV.

Potato Virus Y:--This virus was identified primarily by means of the mottle reaction (9) of Tabasco pepper plants and the immunity of Datura plants. Fifteen isolates were obtained from pepper plants in ten fields. Other isolates have already been obtained from plants of the annual Solanum and Physalis species. All tested isolates caused mottle rather than the lethal necrosis of the Puerto Rican pepper strain (8) of PVY on plants of large Bell Hot pepper. Tobacco etch virus caused a similar mottle disease on Large Bell Hot pepper plants.

The field-infected pepper plants displayed a "vein banding crinkle" disease similar to that shown by plants from which TEV was isolated, in most cases; and a mottle in others.

Cucumber Mosaic Virus:--Plants of Tabasco pepper and of Nicotiana glutinosa were more useful than the other three basic indicators for identifying strains of this virus. On Tabasco plants, local symptoms occur as relatively broad, chlorotic to necrotic single ring and oakleaf patterns. If lesions are not numerous, they gradually increase in size over a considerable period of time. Systemic infection may or may not occur. Symptoms of systemic infection range from mottles to severe necrosis with or without leaf drop.

The well-known mottle reaction of Nicotiana glutinosa plants varies with the virus strain and with environmental conditions. However, the type of mottle is invariably distinct from that caused by TEV and PVY.

The identity of several isolates was confirmed by means of immunological studies in zinnia (7) or California Wonder pepper (1) plants.

Cucumber mosaic virus was obtained from 8 fields, but 6 of them yielded CMV only from plants other than pepper. Among the more interesting source plants were Vinca rosea L., which yielded a distinctive strain systemically infectious to cowpea plants; and Vigna sinensis, which yielded the cowpea strain (4) of this virus. Proof that the cowpea strain infects pepper plants in the field has not yet been obtained.

Aster Ringspot Virus:--The relatively broad yellow ring, line, and oakleaf patterns of this virus (3) were distinctive; and the isolates were identified by visual inspection only. Pepper plants infected with this virus were found in most surveyed fields of Seminole and Volusia Counties, but nowhere else. Restriction of this virus to this area confirms an earlier report (3). In these counties, ARSV attacks pepper fields earlier than TEV, TMV, or PVY.

Weed Sources:--Plants of the Solanum nigrum-S. gracile complex were found near most of the fields examined. In general, diseased Solanum populations seemed to be higher and to appear earlier in Manatee and Hardee Counties.

Commelina nudiflora L. populations were likewise relatively high in the three counties in which CMV was most often obtained. Plants of Ambrosia artemesiifolia L. (ragweed) and Phytolacca rigida Small (pokeweed) were found near a number of pepper fields. Seven isolates from ragweed and four from pokeweed yielded only negative results.

Florida growers often inquire about the apparent mosaic disease of the perennials Chenopodium ambrosioides anthelminticum (L.) A. Gray, Sida rhombifolia L., S. carpinifolia L., and Sambucus simpsoni Rehder, and the annual Bidens pilosa L. Mosaic disease was often noted on plants of these species. However, 14 attempts to obtain pepper viruses from them yielded only negative results.

The annual Indigofera hirsuta L. twice exhibited mosaic disease when growing within etch-infected pepper fields. No virus was obtained from the plants, but greenhouse tests proved that this species is susceptible to both TEV and PVY.

DISCUSSION

Symptoms of field-infected pepper plants were difficult to correlate with the presence of specific viruses. Aster ringspot virus was readable. The "yellow-pod" fruit symptom, as it is termed in Florida, and a light foliage mottle indicated the presence of certain strains of TMV. The etch and Y viruses were associated with the "vein banding crinkle" disease in most cases. Pepper plants suspected of containing CMV sometimes yielded TEV or PVY instead. The identification of pepper viruses from field symptom expression alone is nearly impossible.

Etch virus occurred in more fields than any other virus. The potato Y and tobacco mosaic viruses were second; while the aster ringspot and cucumber mosaic viruses were fourth. Potato virus Y was most commonly encountered in the southwestern area comprising Manatee and Hardee Counties. In striking contrast, TEV was most prevalent and most destructive in Hillsborough County, which lies immediately north of Manatee. High populations of nightshades (Solanum spp.) were present in many fields in all three counties; and it is interesting to note that both TEV and PVY have now been obtained from these plants in central Florida.

The relative prevalence of TMV may be overemphasized, and that of other viruses (particularly CMV and PVY) underemphasized, in Table 1. The two reasons for this statement are that TMV is much easier to transmit from peppers to other host plants than are the other viruses; while separation of the other viruses from complexes with TMV is relatively difficult.

Cucumber mosaic virus was found mainly in the fields of Seminole and Hardee Counties. Only three instances of CMV were noted among 31 fields examined in Alachua, Sumter, Hillsborough, and Manatee Counties. These data substantiate those obtained by earlier workers (2, 5, 13) in which the prevalence of CMV was correlated with the prevalence of Commelina nudiflora plants near the fields.

The "yellow-pod" disease representing cases of infection by some peculiar strains of TMV, and the cases of early TEV infection appeared to cause the most severe losses. The planting of Yolo Wonder peppers in central Florida may have reduced the number of TMV cases reported. However, other viruses were obtained from Yolo Wonder pepper fields.

Viruses which cause diseases in peppers were isolated from plants of Solanum nigrum, S. gracile, S. aculeatissimum Jacq., Physalis angulata, P. ciliosa Rydb., P. elliottii Kze., P. viscosa L., Cucurbita pepo (L.) Britt., Melothria pendula L., Cassia tora, Vigna sinensis, Vinca rosea, and Scoparia dulcis L.

Wellman (13) found that severe damage to celery crops in Florida was correlated with proximity to the fields of certain weeds which furnished important sources of CMV. He secured practical control of this virus in Seminole County by means of weed eradication. Although it is possible that elimination of the important weed sources of TEV, PVY, CMV, and ARSV from the areas around pepper fields would control these viruses, no such results could be expected with TMV. Within central Florida, mosaic disease of peppers and of some of Wellman's important weed sources of CMV is far more widespread than is CMV. Evidently, viruses other than CMV cause much of the mosaic disease found on the weeds, as well as on the peppers.

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CONTROL OF POTATO SEED PIECE DECAY IN SOUTH CAROLINA 1952-1956[1]

William M. Epps

Summary

The use of irrigation to simulate excessive rain following potato planting created environmental conditions favorable for the development of seed piece decay. Thus, excellent data on the control of this disease by means of seed piece treatment were obtained in a season when there was little seed piece decay in the non-irrigated plantings. Streptomycin treatment, either liquid dips or dusts, of the freshly cut seed resulted in good control of seed piece decay as measured by the effect of treatment on the stands and yields obtained. In those tests where this disease was not prevalent, the streptomycin treatments resulted in slight yield increases. Captan dip and dust treatments also gave good control, but this material was inferior to streptomycin; and, in several tests conducted under such environmental conditions that seed piece decay was of negligible importance, it caused a reduction in yield.

Potato seed piece decay, caused by the bacteria Erwinia atroseptica and E. carotovora, occasionally causes severe losses in coastal South Carolina. The losses have been greatest in those seasons in which heavy rainfall occurred during the period immediately after planting. Within the 11-year period 1946-1956, inclusive, widespread heavy losses occurred only in 1948 and 1953. In the other 9 years, damage to the crop was light, varying from zero to about 5 percent, except in low wet spots where local serious damage occurred almost annually.

The widespread occurrence of this disease in 1948 and 1953, even on newly cleared land, indicated that the pathogen or pathogens were universally present in soils of the low country or that they were introduced into these soils with the seed. The severity of the damage appeared to be dependent on the weather conditions during and immediately after the planting season in February.

Freshly cut potato seed planted in moist, well-aerated soil quickly develop a layer of cork tissue over the cut surfaces. This corky layer tends to protect the cut surface from attack by bacterial pathogens present in the soil. When freshly cut seed are planted in a waterlogged soil or heavy rains fall immediately after planting, this layer of cork tissue cannot form because of a lack of oxygen in the soil. The cut surfaces are then attacked and the seed piece is rotted wholly or partially. The end result is a missing hill, a weak plant, or a plant with the symptoms commonly associated with blackleg. This disease complex is referred to as "seed piece decay" in this discussion.

For the control of seed piece decay, it has been recommended that potato seed be cut approximately a week ahead of planting and stored in ventilated slatted boxes in a warm humid environment to allow the cut surfaces to heal or cork over before planting. Two serious disadvantages have restricted the use of this practice: 1) Large growers have lacked adequate storage space to allow proper ventilation for the quantity of seed which they plant. 2) When seed was cut and adverse weather delayed planting, decay sometimes developed in the cut seed, especially during wet weather and in poorly ventilated stacks. This occurred on several farms in 1955 when early February rains delayed planting over the entire coastal area.

METHODS

Tests were initiated in 1952 to study possible effects of chemical seed treatment and the corking of seed on the severity of seed piece decay. Ordinary fungicides and bactericides were used in 1954. In 1955, following the preliminary work of Bonde (1, 2) and Bonde and de Souza (3) at the Maine Experiment Station, several antibiotics, chiefly streptomycin, were used. In 1956, essentially duplicate tests were conducted on non-irrigated and on irrigated plots on which heavy rainfall following planting could be simulated. The irrigated plot

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[1] Technical Contribution No. 266, South Carolina Agricultural Experiment Station, Clemson, South Carolina.

Table 1. Stands and yields resulting from chemical treatment of freshly cut potato seed pieces. Charleston, South Carolina, 1956.

Chemical	Concentration[c]	Dip time	Irrigated		Non-irrigated	
			Stand[a]	Yield[b]	Stand[a]	Yield[b]
None-freshly cut			30.0	144	37.2	243
None-corked			35.2	225	40.4	257
Captan	2 - 100	Instant	39.3	248	38.8	252
	7 1/2%	Dust	36.7	229	38.8	217
Phytomycin	100 ppm	Instant	39.8	253	37.0	260
		1 min.	37.0	242	39.4	239
		5 min.	37.5	249	37.8	217
Agrimycin	100 ppm	Instant	39.3	276	38.8	239
		1 min.	39.2	292	40.2	280
		5 min.	41.0	289	38.0	264
AC Streptomycin	100 ppm	Instant	37.7	256	41.0	245
		1 min.	38.8	252	39.8	264
		5 min.	39.2	294	40.0	261
	50 ppm	Instant	38.5	235	---	---
		1 min.	38.3	255	---	---
		5 min.	40.5	289	---	---
	0.05%	Dust	39.2	274	---	---
	0.10%	Dust	40.2	268	---	---
	0.20%	Dust	39.2	278	---	---
LSD at	5% point		4.0	49.9	2.8	39.3
LSD at	1% point		5.3	66.0	3.7	52.3

[a] Stands: Expressed as mean number of plants in 5or 6 plots of 42 seed pieces per plot.

[b] Yields: Expressed as bushels per acre of U. S. No. 1, Size A potatoes.

[c] Concentrations expressed as parts per million of the active ingredient involved for streptomycin dips. Dust concentrations expressed as percentages of active ingredient. Captan dip concentration expressed as pounds of 75 percent concentrate per 100 gallons of water.

received two irrigations of approximately 1.25 inches each, 1 and 5 days after planting. This irrigation, combined with light rainfall, kept the soil wet for over a month after planting.

Randomized block designs, with 5 or 6 replicates, were used in all tests. The plot size varied from season to season, but, in general, individual plots were either one or two rows each 36 feet 4 inches long. The Sebago variety was used, except where it is stated otherwise.

The chemicals used in the 1956 tests were 1) captan 75% wettable, 2) captan 7.5% dust with Cohutta talc diluent, 3) Phytomycin (streptomycin nitrate 20%), 4) Agrimycin (streptomycin sulfate 15%, oxytetracycline 1.5%), and 5) American Cyanamid Streptomycin (streptomycin sulfate 15%).

The relative effectiveness of the various treatments was determined by measuring the stands and yields of the various plots.

RESULTS

1952 Season: In a test planted in a low poorly drained area, the use of corked seed resulted in an increase in stand from 69 percent for freshly cut seed to 79 percent for corked seed. The increase in yield was from 221 to 351 bushels per acre. This large increase in yield resulted from the increased vigor of the plants grown from the corked seed. Stand

counts indicated that 77 percent of the plants in the treated row were rated as "vigorous" while only 41 percent of those in the check row were so rated. A chloranil dip failed to have any effect on stand or yield.

1953 Season: The use of pre-cut or corked seed in 1953 resulted in a large increase in stand for three varieties of potatoes. The stands, which were poor in all plots, were as follows for the three varieties: Cobbler 72 and 56 percent, Pontiac 71 and 54 percent, and Sebago 31 and 15 percent, for the corked and freshly cut seed, respectively. Yields were not recorded.

1954 Season: Stands and yields were good in 1954. The fungicides captan, dichlone, maneb, and Tribasic Copper Sulfate; the insecticide, heptachlor; and the bactericide, Ottasept, failed to have any appreciable effect on potato stand or yield. In another test, a captan dip (2 pounds 75% captan per 100 gallons of water) resulted in a highly significant yield reduction of 35 bushels per acre. Corking of the seed in 1954 did not produce a measurable increase in yield.

1955 Season: In 1955 the season was again favorable for potato sprout emergence. Streptomycin treatment of freshly cut seed resulted in a slight increase in yield over that from untreated seed. The difference was far short of that required for statistical significance. The captan dip, for the second consecutive year, resulted in a yield reduction (31 bushels per acre less than the control). Planting was delayed by wet weather and some of the pre-cut seed showed some decay when they were planted.

1956 Season: In 1956 the early part of the season was favorable for plant growth and good stands were obtained. Yields were reduced by late season frosts and drought. In the non-irrigated plots, the results (Table 1) were essentially similar to those obtained in 1955. Streptomycin treatment again resulted in a slight increase in yield. The captan dip resulted in a very slight increase and the captan dust a slight decrease in yield.

In the irrigated plots, all treatments resulted in a greatly increased stand and yield (Table 1). Streptomycin was more effective than captan and was also more effective than the currently recommended practice of pre-cutting the seed. Agrimycin 100 and American Cyanamid Streptomycin appeared to be superior to Phytomycin. This difference, which appeared in both irrigated and non-irrigated tests, was possibly due to phytotoxicity of the Phytomycin since this chemical did cause a progressive decrease in yield in the non-irrigated plot as the time of dipping was increased. Streptomycin dust was equal to the streptomycin liquid dip in effectiveness. A dipping time of 5 minutes was slightly more effective than the shorter dipping times, although the differences were slight when compared to the differences between the treated and untreated.

The percent yield increase for all treatments was consistently greater than the percent increase in stand. For example, the increase in stand from the use of corked seed in 1952 was only 14.5 percent, while the increase in yield was 58.8 percent. In 1956, increases in stand in the irrigated plots were 17.3 and 29.7 percent, respectively, for the corked and streptomycin treatments over the control. The yield increases were 56.2 and 85.4 percent, respectively. These figures reflect the reduction in seed piece decay and the increased vigor of plants from the treated seed.

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THE COMPATIBILITY OF CERTAIN ORGANIC FUNGICIDES AND ANTIBIOTICS IN TREATMENT MIXTURES AS INDICATED BY STABILITY AND PHYTOTOXICITY[1]

E. T. Palm and Roy A. Young

Summary

The fungicidal activity of dichlone and captan and the bactericidal activity of streptomycin sulfate, streptomycin nitrate, and Terramycin were not reduced significantly after aqueous mixtures of the fungicides and antibiotics had aged for one week. After the same interval both the fungicidal and bactericidal activities of maneb were significantly reduced. Maneb was not compatible with Terramycin; a mixture of the two compounds was significantly less fungicidal than maneb alone. Maneb showed more bactericidal activity than streptomycin sulfate or nitrate but was less active than Terramycin. None of the mixtures tested were phytotoxic to cut potato seed-pieces.

Pre-planting treatments of cut potato seed-pieces are used commonly by Oregon potato growers to prevent seed-piece decay caused by Fusarium and Pythium species. Growers who use conventional picker planters use a dip treatment in either dichlone or captan immediately after cutting. Following treatment in one of these materials, the seed-pieces may be planted immediately or stored safely for as long as three or four weeks without damage.

Both dichlone and captan have the disadvantage of being relatively non-bactericidal and are ineffective in preventing spread of bacterial ring rot when infected tubers occur in a particular seed lot. To compensate for this deficiency some use has been made of streptomycin formulations in combination with dichlone or captan in treatment mixtures. Little information is available concerning the effectiveness and stability of such mixtures. Since seed-piece treatment mixtures usually are used for from several hours up to a full day, trials were conducted to determine the compatibility of dichlone, captan and maneb with streptomycin and Terramycin formulations as indicated by stability in aqueous mixtures and by phytotoxicity.

METHODS AND MATERIALS

A paper disc assay method[2] was used to determine the bactericidal and fungicidal activities of the several preparations tested. Ten ml of melted PDA was placed in a 9-cm petri dish. After hardening, the surface of the medium was inoculated by spraying Fusarium roseum spores or Bacillus subtilis on each plate to give a uniform distribution of inoculum on the surface of the agar. The plates were put in a 5° C cold room for at least an hour after being inoculated. The plates were then removed, 1/2-inch filter paper discs were placed on the surface of the agar and 1/10 ml of distilled water or test solution was placed on the filter paper discs. Three discs were placed in each plate allowing 3 concentrations of a substance to be tested in each plate. Three replications of each concentration were used. The plates were incubated for 20 to 24 hours at 25° C, after which time the diameter of the zone of inhibition was measured.

The fungicides tested were dichlone, captan and maneb. Antibiotics tested were streptomycin sulfate and Terramycin hydrochloride furnished by Chas. Pfizer and Co., Inc. and streptomycin nitrate furnished by Olin Mathieson Chemical Corporation. Test suspensions of fungicides were prepared by placing sufficient commercial Phygon XL (U. S. Rubber Co.), Orthocide 50 (California Spray Chemical Corp.), or Manzate (Newton Chemical & Supply Co.) in 500 ml of water to give 3000 parts per million of dichlone, captan and maneb. When streptomycin sulfate and nitrate were included in a test solution, they were added to give a final

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[1] Technical Paper No. 1023, Oregon Agricultural Experiment Station.

[2] Loo, Y. H., et al. 1945. Assay of streptomycin by the paper disc plate method. Jour. Bact. 50: 701-709.

Table 1. Compatibility of dichlone with Terramycin, streptomycin sulfate, and streptomycin nitrate.

Preparation	Concentration Ratio	Significance*	Diameter of inhibition zone (mm) at various concentrations of Dichlone (p.p.m.) 0	1.4	5.8	23.4	93.7	375
Assayed against Fusarium roseum								
Dichlone	—	—	0	0.1	3.0	6.0	8.2	-
Dichlone-Terramycin	30-1	n.s.	0	0.1	2.9	7.1	9.8	-
Dichlone-Strep. sulfate	30-2	n.s.	0	0.4	3.2	5.1	7.0	-
Dichlone-Strep. nitrate	30-2	n.s.	0	1.2	2.6	5.2	6.9	-
Assayed against Bacillus subtilis								
Dichlone	—	—	0	-	0	2.2	3.7	6.3
Dichlone-Terramycin	30-1	sign.	0	-	1.3	6.1	14.1	20.9
Dichlone-Strep. sulfate	30-2	n.s.	0	-	0.4	1.7	4.9	7.0
Dichlone-Strep. nitrate	30-2	n.s.	0	-	0.3	2.0	4.7	9.0

* n.s. Not statistically significant from fungicide alone
sign. Statistically significant from dichlone

Table 2. Compatibility of captan with Terramycin, streptomycin sulfate, and streptomycin nitrate.

Preparation	Concentration Ratio	Significance*	Diameter of inhibition zone (mm) at various concentrations of Captan (p.p.m.) 0	2.9	5.8	23.4	93.7
Assayed against Fusarium roseum							
Captan	—	—	0	1.5	4.8	11.3	17.2
Captan-Terramycin	30-1	n.s.	0	1.7	5.0	10.9	14.6
Captan-Strep. sulfate	30-2	n.s.	0	0.1	3.7	10.2	14.3
Captan-Strep. nitrate	30-2	n.s.	0	0.6	3.7	10.4	13.4
Assayed against Bacillus subtilis							
Captan	—	—	0	0	0.3	2.3	5.1
Captan-Terramycin	30-1	sign.	0	-	0.2	6.9	15.1
Captan-Strep. sulfate	30-2	n.s.	0	0	Tr.	2.7	6.6
Captan-Strep. nitrate	30-2	n.s.	0	0	0.1	3.2	6.3

* n.s. Not statistically significant from fungicide alone
sign. Statistically significant from captan

Table 3. Compatibility of maneb with Terramycin, streptomycin sulfate, and streptomycin nitrate.

Preparation	Concentration Ratio	Significance*	Diameter of inhibition zone (mm) at various concentrations of maneb (p.p.m.) 0	2.9	5.8	23.4	93.7	375	3000
Assayed against Fusarium roseum									
Maneb	—	—	0	-	-	0.9	7.5	16.0	26.4
Maneb-Terramycin	30-1	sign.	0	-	-	0.2	5.5	11.3	17.1
Maneb-Strep. sulfate	30-2	n.s.	0	-	-	1.7	8.0	13.7	23.3
Maneb-Strep. nitrate	30-2	n.s.	0	-	-	0.3	7.6	14.9	24.4
Assayed against Bacillus subtilis									
Maneb	—	—	0	0.3	3.2	13.8	26.7	-	-
Maneb-Terramycin	30-1	n.s.	0	Tr.	2.9	14.3	25.3	-	-
Maneb-Strep. sulfate	30-2	n.s.	0	1.9	4.8	15.3	29.2	-	-
Maneb-Strep. nitrate	30-2	n.s.	0	1.4	5.1	17.1	27.2	-	-

* n.s. Not statistically significant from fungicide alone
sign. Statistically significant from maneb

Table 4. Comparison of activity of Terramycin, streptomycin sulfate, and streptomycin nitrate assayed against Bacillus subtilis.

Antibiotic	Diameter of inhibition zone (mm) at various concentrations (p.p.m.) of active ingredient 0	0.19	0.39	0.78	3.1	6.25	12.5	25	50	100	200
Terramycin	0	0.47	3.0	6.7	14.0	16.3	19.4	-	-	-	-
Streptomycin sulfate	0	-	-	-	-	0.4	1.5	3.1	4.9	7.1	9.6
Streptomycin nitrate	0	-	-	-	-	0.5	2.0	4.6	5.6	8.3	10.4

concentration of 200 ppm active ingredient. When Terramycin was included, it was used at the rate of 100 parts per million. The ratio of concentration of fungicides to streptomycin formulations (30-2) in test mixtures approximates levels used commercially. Terramycin was used at a lower concentration as it is much more bactericidal than streptomycin. To determine the fungicidal and bacteridical activities of the various preparations, suitable dilutions were assayed and compared.

To test for stability of the fungicides and antibiotics in mixtures, test mixtures were allowed to stand in flasks in a lighted room in which the temperature varied from about 18° to 25° C. At 24-hour intervals, up to 168 hours, samples were removed and comparatively assayed with fresh mixtures against B. subtilis and F. roseum. Data were analyzed by Tukey's method of testing for significance.

[3] Link, R. F., and D. L. Wallace. Some short cuts to allowances. Mimeograph prepared in connection with research sponsored by the Office of Naval Research.

Table 5. Stability of certain antibiotic and fungicide preparations.

Preparation	Loss of Activity (Hours)			
	vs. B. subtilis		vs. F. roseum	
	24	168	24	168
Terramycin	0	n.s.	-	-
Streptomycin sulfate	0	0	-	-
Streptomycin nitrate	0	0	-	-
Dichlone	0	0	0	0
Dichlone-Terramycin	0	n.s.	n.s.	n.s.
Dichlone-Streptomycin sulfate	0	0	0	0
Dichlone-Streptomycin nitrate	0	0	0	0
Captan	0	0	n.s.	n.s.
Captan-Terramycin	n.s.	n.s.	0	0
Captan-Streptomycin sulfate	0	0	0	0
Captan-Streptomycin nitrate	0	0	0	0
Maneb	0	sign.	0‡	sign.
Maneb-Terramycin	0	n.s.	0‡	n.s.
Maneb-Streptomycin sulfate	0	n.s.	0	sign.
Maneb-Streptomycin nitrate	0	n.s.	0	sign.

*n. s. No statistically significant loss of activity sign. Loss of activity is statistically significant.

‡ Immediate loss in activity occurred when mixtures prepared as compared to maneb alone (Table 4). No additional significant decrease in activity as compared to fresh mixtures of maneb-terramycin.

RESULTS

Compatibility of Dichlone-Antibiotic Mixtures: -- Neither the fungicidal activity of dichlone nor the bactericidal activity of the antibiotics were affected significantly when 100 ppm of Terramycin or 200 ppm of streptomycin sulfate or nitrate were added to 3000 ppm suspensions of dichlone (Table 1).

Mixtures of dichlone and Terramycin were significantly more bactericidal than dichlone or dichlone-streptomycin mixtures. Mixtures of dichlone and streptomycin nitrate or sulfate were slightly but not significantly more bactericidal than dichlone alone.

Compatibility of Captan-Antibiotic Mixtures: -- Results with captan were similar to those obtained with dichlone. Neither the fungicidal activity of captan nor the bactericidal activity of the antibiotics were affected significantly when combined in mixtures (Table 2). All of the antibiotics reduced the fungicidal activity of captan slightly but not significantly.

Mixtures of Terramycin and captan were significantly more bactericidal than captan or captan-streptomycin mixtures Dichlone-streptomycin mixtures were slightly but not significantly more bactericidal than dichlone alone.

Compatibility of Maneb-Antibiotic Mixtures: -- The addition of Terramycin to a maneb suspension significantly reduced the fungicidal activity of maneb (Table 3). The addition of other antibiotic preparations did not result in a reduction in fungicidal activity. The bactericidal activity of the antibiotics was masked by the activity of maneb which was more bactericidal than either streptomycin formulation (Tables 3 and 4). Although Terramycin showed more activity than maneb, the activity of Terramycin was not apparent in the data in Table 3 because of the high concentration ratio of maneb to Terramycin.

Stability of Fungicide-Antibiotic-Mixtures: -- All of the preparations tested except maneb-Terramycin mixtures were relatively stable for 24 hours (Table 5). When maneb and Terramycin were mixed, a significant reduction in the fungicidal activity of maneb occurred immediately (Table 3). No further significant decrease in activity occurred even after 168 hours (Table 5).

After aging 168 hours, several of the preparations showed a reduction in activity. This was especially evident with maneb and maneb-streptomycin mixtures, which showed a significant loss of fungicidal and an obvious though not significant decrease in bactericidal activity after 168 hours. Captan-Terramycin and dichlone-Terramycin mixtures showed a slight but insignificant loss of bactericidal activity. Captan and dichlone-Terramycin showed a slight but insignificant loss in fungicidal activity.

Phytotoxicity: -- None of the mixtures rested were phytotoxic to cut potato seed-piece. One-minute immersion of cut seed-pieces in treatment mixtures did not interfere with subsequent suberization or emergence and growth of young plants.

DISCUSSION

These trials show that dichlone and captan are compatible with streptomycin sulfate, streptomycin nitrate and Terramycin and that mixtures of the compounds can age for as long as a week without significant loss in fungicidal or bactericidal activity. The streptomycin formulations had no effect on the activity of maneb, but maneb showed an immediate loss in activity when combined in a mixture with Terramycin. Maneb was not as stable as dichlone or captan. Both fungicidal and bactericidal activity of maneb decreased significantly after 7 days in suspension. The fungicidal activity of maneb-streptomycin mixtures also decreased significantly after 7 days.

It is interesting to note that although dichlone and captan are usually considered relatively non-bactericidal, both compounds were as active against Bacillus subtilis at concentrations used commercially (3000 ppm) as were the streptomycin formulations at 200 ppm. This observation plus repeated failures in other trials to obtain control of bacterial ring rot (Corynebacterium sepedonicum) of potatoes with dichlone and captan alone or in combination with streptomycin formulations leads one to question the effectiveness of such treatments for control of bacterial ring rot. In view of the much greater bactericidal activity of Terramycin it would appear that this material should be tested further for control of bacterial ring rot.

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CONTROL OF DOWNY MILDEW OF LIMA BEAN[1]

D. F. Crossan, P. J. Lloyd, R. A. Hyre, and J. W. Heuberger[2]

Abstract

Two applications of maneb on lima beans within a month of harvest, when downy mildew was present or forecast, gave excellent control of the disease. Tank-mix zineb or tri-basic copper sulfate also gave adequate disease control. Streptomycin plus copper or glycerin was not so satisfactory for control as the other materials tested. Three bean lines, developed by the United States Department of Agriculture, were evaluated under severe disease conditions and found to be highly resistant to infection by Phytophthora phaseoli Thaxt.

INTRODUCTION

The downy mildew disease of lima bean, caused by Phytophthora phaseoli Thaxt., first appeared in Delaware on the Henderson Bush variety in 1945, although it has occurred on the Fordhook variety since 1904. It is most destructive in the latter part of the growing season if prolonged cool, wet weather prevails. A research project was initiated in 1946 by the Department of Plant Pathology, Delaware Agricultural Experiment Station, to investigate the causal organism, the syndrome of development, and control. Results of the various phases of the work during the period 1946 to 1954, inclusive, have been published.

Heuberger (3), Heuberger and Crossan (4), and Heuberger et al. (5), found that copper and zineb fungicides used as sprays and dusts would give commercial control of the disease. The copper fungicide (Tri-Basic Copper Sulfate) gave some injury but was relatively inexpensive to use. Zaumeyer and Wester (8) were able to control downy mildew in greenhouse tests using commercial preparations of streptomycin at 100 ppm as a spray prior to artificial inoculation of the test plants. A spray containing 25 ppm streptomycin and 25 ppm copper was more effective in control than a spray of 25 ppm of each material used alone, suggesting a synergistic action.

Cox (1), Cox and Hyre (2), and Hyre and Cox (7) studied the physiology of the organism and its persistence in infected refuse, and Hyre (6) developed a reliable method for forecasting the initial occurrence of the disease in the field. Thus, it is now possible to advise growers when a favorable period for downy mildew infection has occurred and when spray applications should begin.

Most growers apply two or three insecticidal sprays on fall beans but do not add a copper fungicide because of the sporadic occurrence of the disease and the additional cost. Also, growers who have used copper sprays object to the leaf injury which it causes. Thus, growers do not follow a protective fungicide program for downy mildew control and, consequently, may suffer heavy losses when it does appear and becomes serious.

In 1956, two experiments were conducted at different locations (Clayton and Newark, Delaware) to: (a) evaluate several new materials for control of downy mildew, (b) determine if two or three sprays during pod development, when timed to the forecasting system, would be sufficient to give commercial control of the disease, and, (c) test several bean lines developed for downy mildew resistance by R. E. Wester of the United States Department of Agriculture.

EXPERIMENTATION AND RESULTS

One test was conducted at Clayton, Delaware, in cooperation with the Wheatley Canning Co. and the United States Department of Agriculture, Horticultural Crops Research Branch. A randomized, replicated block design was used on a site where downy mildew caused a crop failure in 1955. The disease was predicted to occur about mid-August in the area; which it did, appearing in the plot during the blossom period. It caused considerable blossom stalk

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[2] Assistant Research Professor, Graduate Research Assistant, Regional Pathologist (United States Department of Agriculture), and Research Professor, respectively.

Table 1. Control of lima bean downy mildew, Clayton, Delaware, 1956.

Variety and treatment	Concentration (100 gallons)	Percent downy mildew[c]	Yield[d] (pounds per acre)
Thorogreen Variety[a] in Treatment Plots[b]			
Untreated	---	38.00	2523
Maneb[e]	2 pounds	0.40	3819
Tri-basic[e]	4 pounds	9.00	3248
Streptomycin plus Tribasic	100 ppm 1 1/2 pounds	13.00	3282
Streptomycin plus glycerin	100 ppm 1 gallon	25.00	2438
Resistant Lines, Unsprayed			
U.S. 155	---	0.10	3535
U.S. 255	---	0.02	3836
U.S. 355	---	0.03	3367
L.S.D. (.05)			880

[a] Planting date July 12, 1956; plot design randomized block, 4 replications, plots 100 feet long; harvest date September 26.

[b] Fungicides applied August 31 and September 12; 125-150 gallons per acre.

[c] Based on 50 plants pulled at random from 100 feet of treated row. All marketable-size pods removed and graded into healthy and mildewed, then counted and weighed.

[d] Yield expressed as pounds per acre of shelled beans. Sub-samples showed a pod to seed weight ratio of 2:1.

[e] Maneb = manganous ethylenebis [dithiocarbamate]; Tri-Basic = basic copper sulfate ($CuSO_4 \cdot 3\ Cu(OH)_2$).

damage and some leaf damage. The disease then became quiescent until the end of August when rainfall and temperature again became favorable. The first spray applications were made at this time, August 31, when the pods were beginning to fill out. On September 12, the second and final fungicidal applications were made. The plots were harvested 14 days after the second application.

The Clayton plot also included three lines of Thorogreen-type lima beans developed for resistance to Phytophthora phaseoli by R. E. Wester of the United States Department of Agriculture. These were included in the randomized, replicated block design used for the fungicide test but were not sprayed.

The data obtained on control are presented in Table 1.

The data obtained from this test indicate that two applications of a maneb fungicide (Manzate), spaced as much as 12 days apart and applied even after the disease appeared gave excellent control of the disease; in addition, the three resistant bean lines showed a high degree of resistance and favorable yield responses. Tri-Basic, streptomycin plus copper, and streptomycin plus glycerin were not so satisfactory as maneb for control in this test. It is possible that higher concentrations of streptomycin alone or in combination with copper would have given a higher degree of control, particularly if applied before the disease had appeared.

Table 2. Control of lima bean downy mildew, Newark, Delaware. Thorogreen variety, 1956[a].

Treatment[b, c]	Concentration (100 gallons)	Percent downy mildew[d]	Yield[e] (pounds per acre)
Untreated	---	34	1842
Tri-Basic	4 pounds	2	3435
Tri-Basic	7% Cu dust	10	2556
Maneb	2 pounds	1	3991
Nabam[f] plus $ZnSO_4$	2 quarts 3/4 pounds	2	3344
Streptomycin plus glycerin	100 ppm 1 gallon	14	2282
Tennam[f]	2 pounds	24	2414
L.S.D. (.05)			886

[a] Planting date July 16, 1956; Plot design randomized block with 5 replications, plots 30 feet long; harvest date October 3.

[b] Fungicides applied September 5, 13, and 20, 125-150 gallons per acre.

[c] For insect control 3 applications of DDT on all rows.

[d] Based on all of the marketable-size pods on all of the plants in a given treatment row pulled from the plants, divided into infected and healthy groups, counted and weighed.

[e] Yield expressed as pounds per acre of shelled beans. Sub-samples showed a pod to seed weight ratio of 2:1.

[f] Nabam = disodium ethylenebis [dithiocarbamate] ; Tennam 7 = manganous dithiocarbamate.

At a second location (Newark, Delaware) a similar test was conducted. In this instance the resistant lines were not included; instead, several more fungicides were evaluated. Downy mildew appeared initially about September 2 and first applications began on September 5. The period September 5 through September 29 was relatively favorable for development of the disease, consequently, three applications of fungicides were made during this period. The interval from the last spray until harvest on October 3 was 13 days. The data obtained in this test are presented in Table 2.

The data substantiate the results obtained at Clayton in that the maneb fungicide gave excellent disease control and yield response. Tri-Basic spray also performed satisfactorily in this test, as did tank-mix zineb (Dithane D-14 + $ZnSO_4$). None of the other materials tested were as satisfactory for disease control.

DISCUSSION

Since it is possible to successfully predict the initial occurrence of downy mildew of lima beans, an application of a maneb fungicide at the time of the forecast and repeated in 7 to 12 days, depending on the weather following disease prediction, should give commercial control when the plants are within a month of harvest. If the weather is unusually favorable for disease development, or if the time to harvest is longer, a third application may be necessary. Tank-mix zineb and Tri-Basic sprays will control the disease, but to a lesser degree than the maneb fungicide. Streptomycin plus copper or glycerin gave the least control in these tests. Three U. S. resistant lines have been shown to have a high degree of resistance and should be developed further for release to seedsmen.

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STUDIES ON THE CONTROL OF DAMPING-OFF OF SAFFLOWER WITH ANTIBIOTICS[1]

M. L. Gattani[2]

Abstract

Out of five antibiotics tested for inhibition of five root-rotting fungi in vitro, actidione, patulin and filipin gave promising results. As actidione and patulin proved to be phytotoxic to safflower seeds and seedlings, filipin was used for studies on the control of the damping-off phase of the root rot of safflower caused by an unidentified species of Pythium in Alberta.

Seed treatment of safflower with different concentrations of filipin for varying periods did not control the disease. Seven-day-old seedlings of safflower treated with 50 ppm filipin for 72 hours and transplanted in soil infested with Pythium sp. showed 63.3 and 43.3 percent survival after 4 and 6 weeks, respectively, as compared with 5 and 2.5 percent in the control. When seeds of safflower were sown in soil infested with Pythium sp. which was subsequently treated with filipin, the surviving stand in the pots was 60.2 and 43.8 percent after 3 and 6 weeks as compared with 5.1 and 3.0 percent in the controls where the soil was not treated with filipin.

The present state of our knowledge on the use of antibiotics as bactericides and fungicides against plant diseases has been summarized by Ark and Alcorn (2). Most of the work reviewed has been on the control of bacterial diseases or air-borne fungal diseases by antibiotic sprays and little has been published on the use of antibiotics as seed treatment for the control of soil-borne diseases. Although a number of root-rotting fungi normally occurring in soil have been used in testing the antifungal spectrum of antibiotics, apparently few attempts have been made to use antibiotics to control the diseases caused by those fungi. Studies were therefore made on the control of the damping-off stage of the root rot of safflower caused by an unidentified species of Pythium. This disease of safflower, reported by Cormack and Harper (3), has been very destructive in experimental plantings of susceptible varieties of safflower in the irrigated areas of southern Alberta. Preliminary to this study a number of antibiotics were screened for antifungal activity against root-rotting fungi.

SCREENING OF ANTIBIOTICS

Materials: The following antibiotics were used: filipin 94%, and actidione, 7.7% (Actitabs) supplied by the Upjohn Company, Kalamazoo, Michigan; patulin, 100%, streptomycin, 54.2%, and streptothricin, 26%, supplied by Merck and Company Limited, Montreal, Quebec. The concentrations in parts per million employed in this study were based on the original preparations and not on the active ingredient. For infesting individual pots, 100 ml. of the inoculum of Pythium sp., obtained by mixing a 4-day-old petri plate culture in a Waring Blendor with 200 ml. of water, were used.

The inhibitory properties of the antibiotics against root-rotting fungi were determined by their action on Helminthosporium sativum Pamm., King & Bakke, Fusarium culmorum (W. G. Smith) Sacc., Rhizoctonia solani Kuehn, Phoma betae (Oudem.) Frank; and Pythium sp. from safflower. For this, 100 ml. of potato dextrose broth was dispensed in 250-ml. Erlenmyer flasks and different amounts of the antibiotics were added aseptically to give concentrations of 500, 100, 50, 20 and 10 ppm of the antibiotics in the broth. The flasks were inoculated with equal amounts of inoculum and the growth of the fungi on the surface of the liquid medium recorded after 7 days' incubation at 23° C. In this experiment streptothricin and streptomycin were found to be ineffective in inhibiting the growth of the fungi even at concentrations of 500 ppm and more, whereas with filipin, patulin, and actidione, the five

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fungi were inhibited at concentrations varying from 10 to 100 ppm. of the three antibiotics.

PHYTOTOXICITY OF ANTIBIOTICS TO SAFFLOWER

Patulin, actidione and filipin, which showed promising antifungal activity, were tested for their phytotoxicity to seeds and seedlings of safflower. For this purpose, seeds of safflower (Nebraska 9) were soaked in 5000, 500, 50 and 5 ppm concentrations of the antibiotic preparations for 16 hours. They were then washed three times in water and plated on 1.5% water agar plates for germination. The results recorded in Table 1 indicate that the percentage germination of safflower seeds was seriously reduced by patulin and actidione. For filipin treatments at 5000 and 500 ppm, the germination percentage was 37.7 and 43.3, respectively, but at 50 and 5 ppm it was approximately the same as for the control. These results showed, therefore, that patulin and actidione were phytotoxic to seeds and filipin was much less so.

Table 1. Germination of safflower seeds treated for 16 hours with different concentrations of the antibiotic preparations.

Antibiotic preparation	Percentage germination in concentration (p.p.m.)				
	5000	500	50	5	0
Patulin	0	13.3	15.5	34.4	-
Actidione	9	25.5	33.3	58.8	-
Filipin	37.7	43.3	57.7	62.2	-
Control	-	-	-		60

That patulin and actidione were more phytotoxic than filipin was further substantiated by another experiment in which the roots of 7-day-old safflower seedlings were soaked in 100 and 50 ppm concentrations of the three antibiotic preparations for 48 and 72 hours. Although the patulin- and actidione-treated seedlings wilted, the filipin-treated seedlings remained healthy.

CONTROL OF DAMPING-OFF OF SAFFLOWER WITH FILIPIN

As filipin showed fairly good antifungal properties in vitro and was only slightly harmful to germination of seeds and growth of safflower seedlings, experiments were undertaken to determine if filipin would control safflower damping-off, caused by Pythium sp.

Seed Treatment: In the first series of experiments safflower seeds were immersed in 4 concentrations of filipin, 5000, 500, 50 and 5 ppm, for 3 periods: 17, 6, and 1 hour. The seeds were then washed in running water for 2 minutes and seeded in sterile soil artificially infested with Pythium sp. Three replicate pots with 10 seeds per pot were used for the experiment which was repeated three times. Readings were taken 2 weeks after seeding. Seeds treated with 50 and 5 ppm filipin did not germinate in the infested pots, as in the control experiment. With 5000 and 500 ppm filipin treatments there was 23.8 and 9.5 percent germination in the infested pots but the seedlings toppled over in another week. It was, therefore, apparent that damping-off of safflower could not be controlled by treating seeds with filipin.

Root-Soak Treatment: In the next series of experiments roots of 7-day-old safflower seedlings, grown in sterile soil, were soaked in a 50 ppm filipin solution for 72 hours. The

Table 2. Control of damping-off of safflower by treatment of seedlings with 50 ppm filipin for 72 hours.

Treatment of seedlings	Percentage stand after transplanting	
	4 weeks	6 weeks
Control - Nontreated transplanted in sterile soil	100.0	100.0
Control - Nontreated transplanted in *Pythium*-infested soil	5.0	2.5
Roots soaked in filipin for 72 hr.- transplanted in sterile soil	86.6	86.6
Roots soaked in filipin for 72 hr.- transplanted in *Pythium*-infested soil	63.3	43.3

Table 3. Control of damping-off of safflower seedlings by soil treatment with 50 ppm filipin.

Treatment	Percentage stand	
	3 weeks	6 weeks
Control - seeds in sterile nontreated soil	83.5	85.7
Control - seeds in sterile soil treated with filipin	76.0	84.6
Seeds in *Pythium*-infested soil not irrigated with filipin	5.1	3.0
Seeds in *Pythium*-infested soil irrigated with filipin	60.2	43.8

solution was placed in 13.9 x 3.8-mm. petri dishes covered with a 3-mm. plastic sheet in which were drilled 21 holes at equidistant points. Plastic tubes 25 mm. in length and 10 mm. in diameter were placed in the holes so that half projected outside. These were used to support the safflower seedlings so that their roots were submerged in the filipin solution. The seedlings were then transplanted in pots infested with Pythium sp., 30 plants being used for each treatment. The results of this experiment replicated three times are given in Table 2.

Safflower plants developing from seedlings with roots treated with filipin and transplanted into sterile soil were at first slightly stunted when compared with the untreated plants. However, after 4 weeks' growth this stunting disappeared and the plants looked perfectly healthy. The filipin-treated plants when transplanted into infested soil remained healthier than the untreated plants in the infested soil up to the first 4 weeks (Fig. 1).

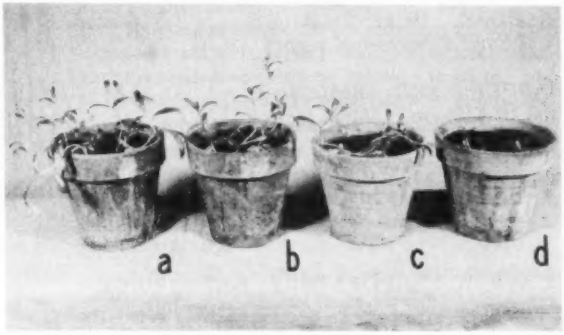

FIGURE 1. Four-week-old seedlings of safflower treated with 50 ppm filipin for 72 hours and transplanted into sterile and Pythium-infested soil. a -- Nontreated seedlings in sterile soil. b -- Treated seedlings in sterile soil. c -- Treated seedlings in Pythium-infested soil. d -- Nontreated seedlings in Pythium-infested soil.

Soil Treatment: In another series of experiments, filipin in solution was added to soil artificially infested with Pythium sp. and its effect on the control of damping-off of safflower seedlings was investigated. Safflower seeds were planted in artificially infested and noninfested soils in 10 pots with 10 seeds per pot. Each day for 3 days, 100 ml. of a 50 ppm filipin solution was added to infested and to noninfested soils in which the seeds were previously sown. The experiment was repeated three times and the results are given in Table 3.

It is evident that the application of filipin solution for 3 days effectively reduced damping-off of safflower.

DISCUSSION

Filipin, an antifungal agent, has been reported to be inhibitive against a wide variety of fungi and to give partial protection to tomato plants against Stemphylium solani (1). Our in vitro investigations show that filipin is inhibitive against Helminthosporium sativum, Fusarium culmorum, Rhizoctonia solani, Phoma betae, and Pythium sp. pathogenic to safflower. In addition, safflower seeds and seedlings were tolerant to filipin. Patulin and actidione also showed very good antifungal properties in the in vitro studies but these substances were phytotoxic to safflower.

When safflower seeds were treated with varying concentrations of filipin and sown in soil infested with Pythium sp., a stand of about 24 percent was obtained with seeds soaked in a 5000 ppm solution for 17 hours as compared with the absence of a stand in the nontreated control. Although this soak treatment was slightly phytotoxic to the seeds, it appears that sufficient filipin was absorbed to give partial protection against the pre-emergence phase of damping-off. However, after the seedlings were established, they damped-off within a week and this suggested that the amount of filipin absorbed by the seed is inadequate to arrest the progress of the fungus.

Seedlings of safflower treated with filipin and transplanted in soil infested with Pythium sp. resisted the attack of the fungus up to 4 weeks. After 6 weeks, however, almost 50 percent damped-off. Filipin showed a slight phytotoxic effect in this test as the treated seedlings remained stunted up to 2 weeks, but after 4 weeks they showed normal growth.

The pre-emergence stage of the damping-off phase of the root rot of safflower caused by

Pythium sp. was effectively controlled by irrigating infested soil with filipin. The treatment of soil with filipin probably retarded the growth of the fungus up to 3 weeks thus partially protecting the seeds against soil-borne infection. It would appear that the dosage of filipin used did not have a complete eradicative effect on the infested soil, as after 3 weeks of the application of filipin there was an increase in the rate of mortality of the seedlings. However, these results suggest that treatment of soil with filipin solutions can be used to control the pre-emergence phase of the damping-off.

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EVALUATION OF FUNGICIDES MIXED WITH THE COVERING-SOIL AT PLANTING AS A CONTROL MEASURE FOR THE COTTON SEEDLING-DISEASE COMPLEX[1]

L. S. Bird, C. D. Ranney and G. M. Watkins[2]

Summary

Fungicides and combinations of fungicides mixed with the covering soil at time of planting for controlling the cotton seedling-disease complex were tested on sandy and clay soil types in Texas in 1955 and 1956.

Some of the fungicides tested were partially effective in controlling the seedling disease complex, in that they helped to maintain higher populations per acre of plants with healthier root systems when compared with the controls.

No single fungicide or mixture of fungicides gave good results in all locations and all soil types, which indicates that at this time no general statewide recommendations can be made. Instead, recommendations will probably have to be made separately for clay and sandy soils.

Data on the fungus relationships in the tests indicated that the better treatments reduced attack by Rhizoctonia solani and Pythium spp. but not Fusarium spp. In fact, where the activity of R. solani and Pythium spp. was reduced, the activity of Fusarium spp. increased. This suggests that the fungicide treatments conditioned the soil microflora so as to permit a more rapid development of Fusarium spp.

The facts gathered to date indicate that when a fungicide, or combination of fungicides, is found that is effective over a range of temperatures, equally effective in clay and in sandy soils, and equally toxic to the fungi R. solani, Pythium spp. and Fusarium spp., and that can be mixed with the covering soil at planting, cotton growers in Texas will have a practical means of greatly reducing losses caused by the seedling disease complex.

The seedling disease complex is one of the major cotton diseases in Texas. The disease loss committee of the Cotton Disease Council estimated that from 1952-1956 an average of 2.17 percent of the potential Texas crop was lost to the seedling disease each year. This represents an accumulated loss of about 426,300 bales of cotton for the 5-year period. The seedling disease complex is caused by any one or more of several soil-borne fungi, among which the more important are Rhizoctonia solani Kuehn, Fusarium spp., and Pythium spp.

The seedling disease complex may be subdivided into four phases: seed rot, pre-emergence damping-off, post-emergence damping-off, and seedling root-rot. Seed rot may be controlled by proper treatment of seed with any of the approved seed treatment materials. Seed treatment alone has very little, if any, effect on pre-emergence or post-emergence damping-off or seedling root rot. The zone of protection conferred by the seed protectant is too limited to prevent infection after the seedling ruptures the seed coat. Efforts have been made to protect the seedling from the seed zone to the soil surface by mixing fungicides in the soil that covers the seed. Tests conducted in 1953 in Tennessee, North Carolina, Mississippi, New Mexico, and South Carolina (1), and in Texas (2) indicated that such treatments may be of value in controlling damping-off of cotton. This paper reports the performance in 1955 and 1956 of fungicides applied in the covering soil at planting as a control measure for the seedling disease complex.

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[1] Cooperative investigation between Texas Agricultural Experiment Station and Field Crops Research Branch, Agricultural Research Service, United States Department of Agriculture.

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Table 1. Test of fungicides mixed with the covering soil at planting as a control measure for the cotton seedling-disease complex. Upland Farm, 1955.

Treatment and approximate rates per acre	Form	Mean stand[a]
PCNB + Captan, 3 pounds each	Dust	55.0
Captan 50%, 5 pounds	Dust	53.7
Captan 50%, 5 pounds	Spray	52.8
Dithane D-14 + $ZnSO_4$, 4 quarts + 1 pound	Spray	49.7
Captan 50%, 7 1/2 pounds	Spray	47.5
Zineb 65%, 5 pounds	Dust	47.3
PCNB + Zineb, 3 pounds each	Dust	46.8
Arasan 50%, 4 pounds	Dust	46.2
Dithane D-14, 6 quarts	Spray	41.3
Dithane D-14, 4 quarts	Spray	41.2
PCNB 75%, 5 pounds each	Dust	40.2
PCNB + Dithane D-14, 3 pounds + 2 quarts	Spray	36.3
PCNB + Captan, 3 pounds each	Spray	34.7
Check - 2	---	33.2
PCNB 75%, 5 pounds	Spray	33.0
Vancide 51ZW, 5 pounds	Dust	32.8
Dithane D-14 + $ZnSO_4$, 5 quarts + 2 pounds	Spray	32.0
PCNB + Arasan, 3 pounds + 2 pounds	Dust	31.3
Check - 1	---	30.2
Vancide 51, 4 quarts	Spray	27.2
PCNB + Dithane Z78, 3 pounds each	Spray	24.7
Vancide 51, 6 quarts	Spray	21.8
PCNB 75%, 7 1/2 pounds	Spray	14.7
PCNB + Vancide 51, 3 pounds + 2 quarts	Spray	14.7
Vancide 51ZW, 5 pounds	Spray	16.7
L.S.D. .05		4.8
.01		6.3

[a] Number of plants per 26.5 feet of row.

1955 Experiments

Tests were planted on the Upland farm (Lufkin fine sandy loam), on the A. & M. Plantation (Miller clay) both near College Station, Texas, and on the Stiles farm near Thrall, Texas (Wilson sandy loam). The test design was a randomized complete block with six replications; treatments and seeding rage were the same in each test.

The fungicides were applied as sprays and dusts. The sprays were applied at the rate of 10 gallons per acre, using two nozzles per row, one a fan-type nozzle placed immediately behind the seed spout with the fan parallel to the row, the second a cone nozzle placed so that it was spraying the soil as the covering devices rolled over the seed. The dust was applied so that the dust blast hit the soil just ahead of the covering devices.

The mean seedling stand for 26.5 feet of row, the fungicides used, rates and form of application for the three tests are given in Tables 1, 2, and 3.

Ten seedlings were pulled at random from the check plots at each location. The lower portion of the hypocotyl of each seedling was cultured on water agar, and the number of infected seedlings was determined. The fungi occurring in the diseased seedlings were identified. These results for the three locations are given in Table 4.

Table 2. Test of fungicides mixed with the covering soil at planting as a control measure for the cotton seedling-disease complex, Brazos Valley Plantation, 1956.

Treatment and approximate rate per acre	Form	Mean stand[a]
Check - 2	---	81.6
Dithane D-14 + $ZnSO_4$, 5 quarts + 2 pounds	Spray	79.1
Check - 1	---	77.8
Dithane D-14, 4 quarts	Spray	76.0
Dithane D-14 + $ZnSO_4$, 4 quarts + 1 pound	Spray	73.3
PCNB + Dithane D-14, 3 pounds + 2 quarts	Spray	73.1
Vancide 51, 6 quarts	Spray	72.6
Captan 50%, 7 1/2 pounds	Spray	71.1
Vancide 51ZW, 5 pounds	Spray	70.5
PCNB + Captan, 3 pounds each	Spray	70.3
Zineb 65%, 5 pounds	Dust	70.1
PCNB + Captan, 3 pounds each	Dust	70.1
PCNB + Dithane Z78, 3 pounds each	Spray	70.0
PCNB + Zineb, 3 pounds each	Dust	69.5
Arasan 50%, 4 pounds	Dust	69.5
Dithane D-14, 6 quarts	Spray	69.5
PCNB + Vancide 51, 3 pounds + 2 quarts	Spray	69.1
PCNB 75%, 5 pounds	Dust	68.8
Captan 50%, 5 pounds	Spray	68.5
Captan 50%, 5 pounds	Dust	68.5
PCNB 75%, 7 1/2 pounds	Spray	68.5
PCNB + Arasan, 3 pounds + 2 pounds	Dust	67.3
PCNB 75%, 5 pounds	Spray	66.0
Vancide 51, 4 quarts	Spray	64.0
Vancide 51ZW, 5 pounds	Dust	63.6

No significant difference

[a] Number of plants per 26.5 feet of row.

The 1955 results given in Table 4, along with the performance of the checks in the three tests, show that the Upland farm test was the only one where seedling disease was a problem. In this test several fungicides and mixtures of fungicides gave significantly better stands than the checks. The dust and spray treatments were equally effective. In the Thrall test, a number of fungicides gave significantly lower seedling stands than the checks. This indicates that possibly at the rates applied these fungicides were phytotoxic, or were toxic to the group of soil microflora antagonistic to the pathogens. These data also show that dust applications as a group tended to be more toxic than sprays. In the Plantation test, where the disease organisms were not active and differences were not significant, the same general picture as given in the Thrall test was present. It should be noted that some fungicides applied as a spray appeared toxic in the Thrall test but were not toxic in the Plantation test. This suggests a fungicide x soil interaction.

1956 Tests

Since, as a group, the fungicides which were applied as dusts tended to be toxic in the 1955 tests, only spray applications were made in 1956. Tests were planted at two locations

Table 3. Test of fungicides mixed with the covering soil at planting as a control measure for the cotton seedling-disease complex, Thrall, Texas, 1955.

Treatment and approximate rate per acre	Form	Mean stand[a]
Check - 2	---	47.3
Dithane D-14 + $ZnSO_4$, 4 quarts + 1 pound	Spray	47.0
Captan 50%, 7 1/2 pounds	Spray	46.6
PCNB + Dithane D-14, 3 pounds each	Spray	46.1
Check - 1	---	46.1
Vancide 51, 6 quarts	Spray	44.0
PCNB + Dithane Z78, 3 pounds each	Spray	43.5
PCNB 75%, 5 pounds	Spray	43.3
PCNB 75%, 7 1/2 pounds	Spray	43.0
PCNB + Vancide 51, 3 pounds + 2 quarts	Spray	41.3
Vancide 51, 4 quarts	Spray	40.3
Vancide 51ZW, 5 pounds	Dust	38.5
Captan 50%, 5 pounds	Spray	37.1
Arasan 50%, 4 pounds	Dust	36.1
Captan 50%, 5 pounds	Dust	35.8
PCNB 75%, 5 pounds	Dust	35.5
Dithane D-14, 6 quarts	Spray	34.6
PCNB + Zineb, 3 pounds each	Dust	34.5
PCNB + Captan, 3 pounds each	Spray	34.3
Zineb 65%, 5 pounds	Dust	33.6
Vancide 51ZW, 5 pounds	Spray	33.1
PCNB + Captan, 3 pounds each	Dust	32.6
Dithane D-14, 4 quarts	Spray	32.5
PCNB + Arasan, 3 pounds + 2 pounds	Dust	32.3
Dithane D-14 + ZnSo , 5 quarts + 2 pounds	Spray	27.1
L.S.D. .05		7.7
.01		10.1

[a] Plants per 26.5 feet of row.

in each of three areas of the State. In each area one test was planted on a clay type soil and the other on a sandy type soil. The areas and locations were: Wharton County, Krenek farm (clay soil), Cerny farm (sandy soil); College Station, Upland farm (sandy soil), Brazos Valley (clay soil); and Hunt County, U. S. Cotton Field Station, (clay and sandy soils).

The arrangement of the spray nozzles on the planter was modified for the 1956 plantings. Three cone type nozzles were used, two placed so that they were spraying the soil immediately ahead of each covering device, the third placed so that it was spraying the soil as it was being rolled over the seed. The sprays were applied at the rate of 10 gallons per acre.

The same tractor, planting and sprayer equipment, and seed supply were used for each test. At all locations approximately 1 to 1 1/2 inches of rain fell during the first 2 weeks after planting. Stand counts were made 21 to 25 days after emergence. The test design was a randomized complete block with six replications.

The mean seedling stand for 26.5 feet of row, fungicides used, and rates of application for the two tests, at each of the three areas, are given in Tables 5, 6, and 7. A summary of the tests is presented in Table 8.

Twenty seedlings were pulled at random from each treatment row of one replication at each of the six locations. In addition, 20 seedlings were pulled from the control row in two additional replications at each location. The lower portion of the hypocotyl of each seedling

Table 4. Total percentage of seedlings infected, and percentage with Rhizoctonia solani, Pythium spp., or Fusarium spp., 1955 and 1956 tests.

Year and location	Percent seedlings infected	Percent of seedlings infected by: Rhizoctonia	Pythium	Fusarium
1955				
Upland Farm	73	12	75	13
Brazos Valley	18	77	23	0
Thrall	20	67	0	33
1956				
Wharton County[a]	93	29	5	66
Clay	85	45	4	51
Sand	100	14	6	80
College Station[a]	78	57	1	42
Clay	97	79	0	21
Sand	69	35	2	63
Hunt County[a]	52	14	35	51
Clay	55	15	9	76
Sand	48	13	61	26

[a] Averages for the two tests in each area.

Table 5. Test results of fungicides mixed with the covering soil for controlling cotton seedling disease complex in Wharton County, Texas, 1956[a].

Fungicide and rate of application per acre	Average number of seedlings per 26.5 feet of row: Mean for the two tests	Krenek farm clay soil	Cerny farm sandy soil
Captan + PCNB; 3 lbs. each	90.5	78.8	102.3
Captan + Zineb; 3 lbs. each	89.5	74.6	104.3
Captan + Dithane D-14; 3 lbs. and 3 qts.	89.0	79.1	99.0
Captan + PCNB + Zineb; 1 1/2, 1 1/2 and 2 lbs.	88.5	77.1	100.0
Dithane D-14; 4 qts.	85.0	81.0	89.1
PCNB + Zineb; 2 lbs. and 4 lbs.	83.8	74.6	93.0
Puratized Agr. Spray; 1 qt.	82.5	67.1	97.8
Dithane D-14 + $ZnSO_4$; 4 qts. and 3/4 lbs.	82.0	79.1	84.8
Captan 50W; 5 lbs.	81.0	75.0	87.1
Vancide 51; 4 qts.	80.5	71.5	89.6
Vancide 51 + Zineb; 2 qts. and 3 lbs.	79.7	71.5	88.0
Zineb 65%; 5 lbs.	77.9	66.3	89.5
PCNB 75%; 5 lbs.	76.3	71.5	81.1
Control; water	72.0	63.6	80.3
L.S.D. .01	12.8	N.S.D.	15.5
.05	9.7		11.7

[a] Conducted in cooperation with Mr. Larry Burleson, County Agricultural Agent.

Table 6. Test results of fungicides mixed with the covering soil for controlling cotton seedling disease complex at College Station, Texas, 1956.

Fungicide and rate of application per acre	Average number of seedlings per 26.5 feet of row: Mean for the two tests	Brazos Valley clay soil	Upland Farm sandy soil
Zineb 65%; 5 lbs.	72.5	54.5	90.5
PCNB + Zineb; 2 lbs. and 4 lbs.	72.5	59.6	85.5
Vancide 51; 4 qts.	71.5	57.0	86.1
Dithane D-14; 4 qts.	71.0	65.5	76.5
Captan 50W; 5 lbs.	67.5	54.0	81.1
Dithane D-14 + $ZnSO_4$; 4 qts. and 3/4 lb.	67.4	57.8	77.0
Captan + Zineb; 3 lbs. each	64.6	56.8	72.5
Captan + PCNB + Zineb; 1 1/2 lbs, 1 1/2 lbs. and 2 lbs.	62.1	64.0	60.3
Captan + Dithane D-14; 3 lbs. and 3 qts.	59.5	52.3	66.8
Captan + PCNB; 3 lbs. each	59.4	62.6	56.1
PCNB 75%; 5 lbs.	59.0	61.3	56.6
Vancide 51 + Zineb; 2 qts. and 3 lbs.	57.4	53.1	61.6
Puratized Agr. Spray; 1 qt.	50.6	53.8	47.5
Control; Water	49.6	44.8	54.5
L.S.D. .01	21.0	N.S.D.	31.7
.05	15.9		23.86

Table 7. Test results of fungicides mixed with the covering soil for controlling cotton seedling disease complex in Hunt County, Texas, 1956[a].

Fungicide and rate of application per acre	Average number of seedlings per 26.5 feet of row: Mean for the two tests	Hunt clay	Wilson sandy loam
Vancide 51; 4 qts.	77.5	66.0	89.0
Dithane D-14 + $ZnSO_4$; 4 qts. and 3/4 lb.	77.1	67.0	87.3
Captan + Zineb; 3 lbs. each	72.7	68.3	77.1
Dithane D-14; 4 qts.	71.2	60.8	81.6
Captan + Dithane D-14; 3 lbs. and 3 qts.	70.9	67.3	74.5
PCNB 75%; 5 lbs.	69.1	64.0	74.3
Captan + PCNB; 3 lbs. each	68.9	53.0	84.8
Captan + PCNB + Zineb; 1 1/2 lbs., 1 1/2, and 2 lbs.	66.1	67.5	64.8
Puratized Agr. Spray; 1 qt.	65.1	53.5	76.8
PCNB + Zineb; 2 lbs. and 4 lbs.	63.9	52.6	75.1
Captan 50W; 5 lbs.	63.4	49.1	77.6
Zineb 65%; 5 lbs.	61.4	45.6	77.1
Control; water	61.1	40.5	81.8
Vancide 51 + Zineb; 2 qts. and 3 lbs.	60.0	51.8	68.3
L.S.D. .01	N.S.D.	N.S.D.	N.S.D.
.05			

[a] The tests were conducted on the U. S. Cotton Field Station, Greenville, Texas.

Table 8. Summary of test results of fungicides mixed with the covering soil for controlling cotton seedling disease complex in Texas, 1956.

Fungicide and rate of application per acre	Average number of seedlings per 26.5 feet of row: Grand mean, six tests[a]	Mean for clay soils, three tests[b]	Mean for sandy soils three tests[c]
Vancide 51; 4 qts.	76.5	64.8	88.2
Dithane D-14; 4 qts.	75.7	69.1	82.4
Captan + Zineb; 3 lbs. each	75.6	66.6	84.6
Dithane D-14 + $ZnSO_4$; 4 qts. and 3/4 lb.	75.5	68.0	83.0
PCNB + Zineb; 2 lbs. and 4 lbs.	73.4	62.3	84.5
Captan + Dithane D-14; 3 lbs. and 3 qts.	73.1	66.2	80.1
Captan + PCNB; 3 lbs. each	72.9	64.8	81.1
Captan + PCNB + Zineb; 1 1/2, 1 1/2 and 2 lbs.	72.3	69.5	75.0
Captan 50W; 5 lbs.	70.6	59.3	82.0
Zineb 65%; 5 lbs.	70.6	55.5	85.7
PCNB 75%; 5 lbs.	68.1	65.6	70.7
Puratized Agr. Spray; 1 qt.	66.1	58.1	74.0
Vancide 51 + Zineb; 2 qts. and 3 lbs.	65.7	58.8	72.6
Control; water	60.9	49.6	72.2
L.S.D. .01	10.6	15.3	13.1
.05	8.0	11.2	9.6

[a] Differences between areas and locations within areas were highly significant.
[b] The area x fungicide interaction was not significant.
[c] The area x fungicide interaction was highly significant.

Table 9. Summary of plating results to determine relative proportions of fungi causing seedling diseases in Texas as affected by fungicide treatments applied in the covering soil, 1956.

Fungicide and rate of application statistically ranked	Percent[a] seedlings infected	Percent of seedlings infected by[a]: Fusarium	Rhizoctonia	Pythium
Vancide 51; 4 qts.	54.29	56.27	23.43	20.00
Dithane D-14; 4 qts.	61.43	55.29	30.14	14.57
Captan + Zineb; 3 lbs. each	74.29	56.72	28.71	14.57
Dithane D-14 + $ZnSO_4$; 4 qts. and 3/4 lb	65.71	64.71	27.57	7.71
PCNB + Zineb; 2 lbs. and 4 lbs.	55.71	73.43	15.71	10.86
Captan + Dithane D-14; 3 lbs. and 3 qts.	53.57	74.00	15.14	10.86
Captan + PCNB; 3 lbs. each	60.71	81.57	13.72	4.71
Captan + PCNB + Zineb; 1 1/2, 1 1/2 and 2 lbs.	68.57	67.71	15.29	17.00
Captan 50W; 5 lbs.	68.57	64.57	29.29	6.14
Zineb 65%; 5 lbs.	57.14	63.86	22.14	14.00
PCNB 75%; 5 lbs.	58.57	77.00	17.29	5.71
Puratized Agr. Spray; 1 qt.	60.71	68.14	28.29	3.57
Vancide 51 + Zineb; 2 qts. and 3 lbs.	62.86	66.29	30.86	2.86
Control; water	75.86	54.29	33.71	12.00
Average of all fungicide treatments	----	66.91	22.89	10.20

[a] Based on platings made from each of 6 locations, 20 seedlings for each fungicide treatment and 60 seedlings for the control at each location.

was cultured on water agar, and the number of infected seedlings and the fungi occurring on the infected seedlings were determined. Check data for the three areas are summarized in Table 4. Individual treatment data are summarized in Table 9.

In the average for the Wharton County tests, five treatments gave significantly higher stands than the control. On the clay soil the differences were not significant; however, the control had the poorest stand. On the sandy soil, five treatments gave significantly better stands than the control. In the College Station tests, four fungicides were effective in improving stands. Performance on the clay and sandy soils was similar to that of the Wharton tests. In the Hunt County tests, differences were not significant; however, the control had the poorest stand in the clay soil. On the other hand, the control had a good stand in the sandy soil. The summary for all six tests shows that eight treatments gave significantly better stands than the control. The control had an average acre population of about 30,000 plants, whereas the better treatments gave 36,000 plants per acre, or an increase of about 20 percent.

The summary data, as well as the data for the area tests, show that some of the treatments that were good on the clay soils were not so good on the sandy soils. The summary data also show that treatments that were good on the clay soil were also good on other clay soils, but this was not the case for the sandy soils, where considerable variation was noted.

The better treatments tended for the most part to be the mixtures of two or more fungicides. Exceptions were Vancide 51 and Dithane D-14, used singly. It is very apparent that some of the single materials, notably captan, zineb, PCNB, and Puratized Agricultural Spray, at the rates used, were not effective.

DISCUSSION AND CONCLUSION

These results show that fungicides mixed in the covering soil at time of planting are effective in at least partially controlling the seedling-disease complex of cotton. Not only do they help maintain higher plant populations per acre, but the plants on the average have healthier root systems.

The fact that no single fungicide or mixture of fungicides gave good results over all locations on all soil types indicates that at this time no general recommendations for Texas can be made. Instead, future recommendations will probably have to be made separately for clay and sandy soils. It will take at least another year of testing before it can be determined just which treatments will be best for a particular soil type.

The data (Table 9) on the fungus relationships in the tests indicate that the better treatments reduced attack by Rhizoctonia solani and Pythium spp., but not by Fusarium spp. On the contrary, where activity of R. solani and Pythium spp. was reduced, activity of Fusarium spp. increased. This suggests that the fungicide treatments conditioned the soil microflora so as to permit a more rapid development of Fusarium spp.

These facts, along with those reported by Ranney and Bird (3), point out that the ideal fungicide or mixture of fungicides for controlling the seedling-disease complex in Texas will have to be effective over a large temperature range, be equally effective on clay and sandy soil, and be equally toxic to Rhizoctonia solani, Pythium spp. and Fusarium spp.

It is felt that some of the improvement in the 1956 results over those of 1955 was due to spray application and to more efficient arrangement of the sprayer nozzles, which led to a more thorough mixing of the fungicides with the covering soil. Other nozzle arrangements are being tried, and it is possible that further improvements can be made.

Results which have been obtained to date suggest that the practice of applying fungicides in the covering soil will be another tool which the cotton grower can use profitably for reducing losses caused by the seedling-disease complex.

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TEXAS AGRICULTURAL EXPERIMENT STATION AND FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

TREATMENT OF BLACK ROOT ROT INFESTED SOIL WITH VAPAM, CHLOROBROMOPROPENE, AND ALLYL BROMIDE

William Lautz[1]

Abstract

Five-gallon samples of soil infested with Thielaviopsis basicola (Berk. & Br.) Ferr. were treated with allyl bromide at the rate of 3 gallons per 200 gallons of water; Vapam (Stauffer N-869) (40% sodium N-methyl dithiocarbamate dihydrate) at 1/40, 1/100, and 1/200 gallons; and chlorobromopropene at 3 gallons per 100 gallons of water. The black root rot disease was controlled effectively by all the chemicals at these concentrations and apparently eliminated by allyl bromide and by Vapam at the 2 stronger concentrations.

INTRODUCTION

Clayton et al. (2) used DD and cyanamid unsuccessfully and Urea at 1 to 1 1/2 lbs. per square yard successfully against black root rot in tobacco beds. Chloropicrin at 4 to 6 ml per square foot (1), ferrous sulfate at 10-15% (3), formalin 2 gallons per 50 gallons, methyl bromide at 2 pounds per 100 cubic feet (5), and steaming (4) have been recommended (6) as control measures against black root rot in seedbeds. Steinberg and Clayton (7) treated black root rot infested soil with calcium cyanamide, urea, and other chemicals. Urea at 12 grams per gallon of soil "gave satisfactory protection for the first and some of the second planting." Zentmeyer and Hendrick (8) controlled Thielaviopsis basicola in soil in glass jars with chloropicrin at 1.9 ml/cu. foot, ethylene oxide at 1.4 ml/cu. foot, 3-dichloropropene at 2.1 ml/cu. foot, and carbon disulfide at 8.4 ml/cu. foot.

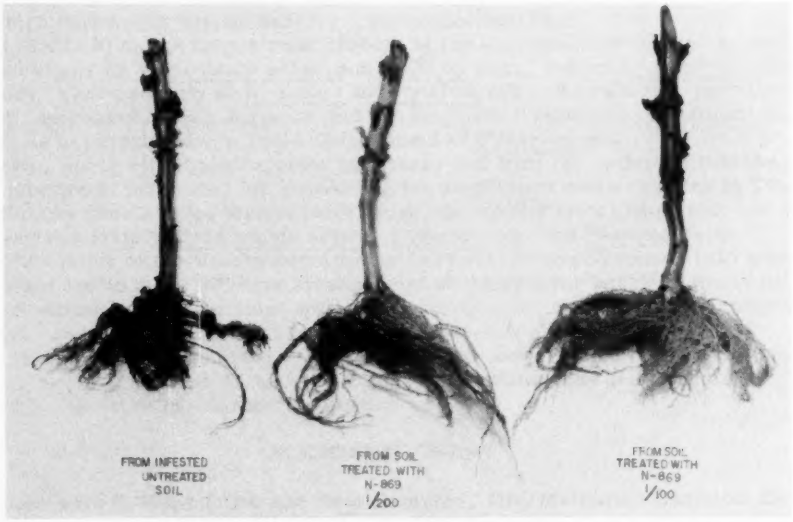

FIGURE 1. Appearance of roots of tobacco plants in black root rot infested soil, untreated, and treated with Vapam (Stauffer N-869).

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Table 1. Heights of plants in black root rot infested soil treated with 3 chemicals.

Treatment	Plants No.	Height in inches		
		Maximum	Minimum	Mean
Sterile soil - untreated	12	43	21	32.5
Infested soil - untreated	12	24	7	13.6
Vapam 1/40	6	44	19	31.7
Vapam 1/100	6	44	29	34.0
Vapam 1/200	6	42	17	34.7
Chlorobromopropene 3/100	6	40	25	33.2
Allyl bromide 6 qt./100 gal.	6	43	31	37.0

Table 2. Black root rot disease indices of plants in infested soil treated with 3 chemicals.

Treatment	Disease indices
Sterile soil - untreated	0,0,0,0,0,0,0,0,0,0,0,0*
Infested soil - untreated	4,4,4,4,4,4,4,4,3,4,4,4**
Vapam 1/40	0,0,0,0,0,0
Vapam 1/100	0,0,0,0,0,0
Vapam 1/200	0,0,1,1/16,0,0
Chlorobromopropene 3/100	1/16,0,1/8,0,0,0
Allyl bromide 6 qt./100 gal.	0,0,0,0,0,0

* Disease index 0 - plant free of disease
** Disease index 4 - plant roots completely diseased

METHODS

Infested soil in 4-gallon lots was treated in pails with 4 quarts of each chemical solution. The different treatments were allyl bromide, 3 gallons per 200 gallons of water; chlorobromopropene, 3 gallons per 100 gallons of water; and Vapam, 1/40, 1/100, and 1/200 gallons. Pails were covered with Visking plastic for 24 hours and the cans then left outside in late summer for 4 days. Treated soil was put into glazed 1-gallon crocks 12 days after treatment. The crocks were watered 3 times to remove chemical residues. Nineteen days after treatment, a tobacco plant approximately 7 inches high, of variety 402, was transplanted into each crock. Plants were removed from the soil and examined 109 days after treatment.

RESULTS

Table 1 gives maximum, minimum, and mean heights of plants in each treatment series at the time of flower bud formation. Table 2 gives disease indices. Comparison of both sets of figures by means of the "t" test shows differences to be significant with a probability of 99:1 between soil treated with any of the chemicals and untreated soil. Figure 1 shows typical roots of plants in untreated and treated soil. The other 5 plants in the Vapam 1/200 series were less infected than the one photographed.

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FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

EFFECT OF SOIL pH ON THE INCIDENCE OF THREE SOIL-BORNE DISEASES OF TOBACCO[1]

Randall R. Kincaid and Nathan Gammon, Jr.[2]

Abstract

Test crops of tobacco have been grown under shade for three seasons on quadruplicate field plots, adjusted to five different pH levels with elemental sulphur and hydrated lime. Each year the incidence of blackshank (Phytophthora parasitica var. nicotianae) in a susceptible variety varied directly with soil pH; differences were highly significant. Blackshank in resistant varieties rose significantly with increasing soil pH to 5.5 - 5.7; above this range, differences were generally not significant. The incidence of root knot (Meloidogyne sp.) and of coarse root (Pratylenchus sp. and others) varied inversely with soil pH; differences were significant, especially for 1956.

EXPERIMENTAL

The incidence of blackshank varied directly with soil pH for 1954, as previously reported[3]. The experiment has been continued through the 1955 and 1956 seasons. Further applications of sulfur and lime have been made between crop seasons to individual plots, in an attempt to maintain differences between the five pH levels, and to reduce differences among the four plots at each level. Soil pH readings were generally increasing during the crop season. The pH values reported are simple averages of readings made for two rows (fumigated and unfumigated) in each plot at each of three dates during the crop season.

Varieties of tobacco used in the experiment were as follows: No. 870, highly susceptible to blackshank; Connecticut 49, moderately susceptible to blackshank, susceptible to root knot and coarse root; Rg, resistant to blackshank, susceptible to root knot and coarse root; and Dixie, highly resistant to blackshank, moderately resistant to root knot, and highly susceptible to coarse root.

The three rows in each plot were managed as follows: One row (unfumigated) was interplanted with 870 and Dixie in 1954, and with 870, Connecticut and Dixie in 1955 and 1956. A second row (fumigated each year with ethylene dibromide) was transplanted to Dixie in 1954, and to Rg in 1955 and 1956. The third row (unfumigated) was transplanted to Dixie each season.

The number of plants dead or severely stunted by blackshank was counted at intervals of about a week. The percentage of affected plants of the susceptible variety about 1 month after transplanting, and of all varieties about 3 months after transplanting is reported. Shortly after the end of leaf harvest, all of the plants were pulled and rated for severity of root diseases on scales of 0 to 100; the average ratings are reported as root disease indexes.

RESULTS

Results, given in Table 1, include least significant differences between means. Some interesting and significant results may be pointed out.

Blackshank in the highly susceptible variety (No. 870) varied directly with soil pH for each of the three seasons: differences were highly significant.

Blackshank in moderately to highly resistant varieties (Connecticut 49, Rg, and Dixie) rose significantly with increasing soil pH to 5.5 - 5.7. Between this range and pH 6.2, the limit of the experiment to date, differences were not significant.

Root Knot varied inversely with soil pH for 1954 and 1955, but results were not significant. All four sets of results for 1956 were significant, three of them being highly significant.

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[1] Florida Agricultural Experiment Station Journal Series, No. 595.

[2] Plant Pathologist, North Florida Experiment Station, Quincy, Florida, and Soils Chemist, Agricultural Experiment Station, Gainesville, Florida

[3] Kincaid, R. R., and Nathan Gammon, Jr., 1954. Incidence of tobacco blackshank directly related to soil pH. Plant Dis. Reptr. 38: 852-853.

Table 1. Incidence of blackshank, root knot, and coarse root of tobacco at five soil pH levels, 1954-1956.

Season	Soil pH	Blackshank (dead or stunted) No. 870[a] 1 mo. %	3 mo. %	Blackshank index Conn.[a] %	Dixie[a] %	Dixie Fum. %	Dixie Unfum. %	Root knot index Conn.[a]	Dixie[a]	Dixie Fum.	Dixie Unfum.	Coarse root index Conn.[a]	Dixie[a]	Dixie Fum.	Dixie Unfum.
1954	4.46	24	58	-	-	1	1	-	-	2	2	-	-	2	14	-	-	85	75
	5.13	67	100	-	-	0	2	-	-	0	4	-	-	2	14	-	-	78	68
	5.53	74	95	-	-	2	2	-	-	3	10	-	-	3	5	-	-	71	71
	5.78	83	100	-	-	2	1	-	-	4	4	-	-	1	4	-	-	73	67
	6.21	88	100	-	-	2	3	-	-	5	6	-	-	2	3	-	-	68	61
L.S.D.,5%		26	24			-	-			4	5			-	17			16	15
1%		36	34			-	-			6	7			-	24			23	21
						Rg[b]				Rg[b]				Rg[b]				Rg[b]	
1955	5.04	43	77	17	2	1	0	-	-	1	4	-	-	2	2	-	-	84	90
	5.28	89	97	24	4	2	0	-	-	5	4	-	-	4	2	-	-	84	89
	5.48	100	100	42	7	0	0	-	-	14	6	-	-	1	1	-	-	82	91
	5.72	98	100	40	2	3	1	-	-	27	6	-	-	1	0	-	-	86	88
	6.00	100	100	55	2	5	1	-	-	25	4	-	-	0	0	-	-	84	92
L.S.D.,5%		14	10	34	8	4	-			8	-			-	-			-	-
1%		20	13	48	12	6	-			11	-			-	-			-	-
						Rg[b]				Rg[b]				Rg[b]				Rg[b]	
1956	5.26	12	100	10	2	0	1	52	14	11	8	22	19	26	7	90	91	89	92
	5.57	16	100	21	0	0	0	64	20	24	13	12	8	15	6	86	82	80	82
	5.76	36	100	41	2	0	0	74	17	28	19	7	8	10	4	91	83	77	79
	5.84	49	100	30	0	2	1	60	17	28	12	4	2	6	2	90	81	73	80
	6.24	52	100	29	2	0	0	63	22	27	16	2	0	2	1	88	78	66	77
L.S.D.,5%		17	-	23	-	-	-	22	14	11	10	5	5	12	5	8	9	8	8
1%		24	-	33	-	-	-	31	19	16	14	7	8	17	7	11	13	12	12

[a] Grown in the interplanted row of each plot.

[b] Substituted for Dixie in 1955 and 1956.

Coarse Root varied inversely with soil pH for 1954 and 1956. Differences were significant in one set of results out of two for 1954, and in three out of four for 1956.

DISCUSSION

Blackshank and the nematode diseases, root knot and coarse root, responded in opposite directions to soil pH as adjusted by additions of sulfur and lime. Yield response, as affected by the incidence of these diseases, would probably depend on their relative severity.

Yield data for 1954 and 1955 showed significant differences in only one instance. The yield of Rg on fumigated soil for 1955 was inversely related to soil pH. Blackshank, which showed relatively large differences, was probably the most important disease factor in determining the yield, because the incidence of root knot was so low that it was probably not important, and the incidence of coarse root was quite uniformly high.

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RESISTANCE IN TOMATO TO MELOIDOGYNE JAVANICA AND M. INCOGNITA ACRITA

Ivan J. Thomason and Paul G. Smith

Abstract

A tomato line (HES 4857) derived from a cross of Lycopersicon esculentum x L. peruvianum was found to be highly resistant to the root-knot nematode, Meloidogyne incognita acrita. Resistance is governed by a single dominant gene. An F_3 line (54N6) from a backcross of HES 4857 x commercial tomato was resistant to M. javanica and M. incognita acrita.

Breeding of varieties of tomatoes resistant to root-knot nematodes, Meloidogyne spp., is being conducted by workers in a number of Experiment Stations in continental United States, Hawaii, Australia, and perhaps elsewhere. So far as known, all resistant tomato stocks now in use derive their resistance from a single cross, Lycopersicon esculentum (Michigan State Forcing) x L. peruvianum (P. I. 128,657) (3) made in 1943.

Sasser (2) has reported L. peruvianum to be very highly resistant to Meloidogyne incognita but susceptible to M. incognita acrita and M. javanica. Gilbert and McGuire in Hawaii (1) postulate a single dominant gene for resistance to an undetermined species of Meloidogyne in tomato lines derived from the above cross. Winstead and Barham (4) reported that the tomato line Hawaii 5229 was resistant to four species of root-knot nematodes (M. incognita, M. incognita acrita, M. javanica, and M. arenaria) and susceptible to one, M. hapla. Their data indicated that the same gene controls resistance to each of these four species and that the resistance is incompletely dominant.

The tomato material, HES 4857, used in these experiments was obtained from Dr, D. C. McGuire of the Hawaii Agricultural Experiment Station and was at the fourth backcross level. This stock was homozygous resistant to nematode infection in Hawaii. When planted at Davis, California into soil heavily infested with M. incognita acrita all plants were classed as resistant although not rated by a numerical scale. Two further backcrosses were made to commercial tomato varieties, the plants were then grown from 8 to 10 weeks in infested soil and were rated for infection on a scale of 1 to 4. Our ratings of 1, 2 and 3 correspond closely with Sasser's (2) ratings of 0, 1 and 2. Our rating 4 was essentially a combination of his rating 3 and 4.

Grouping classes 1 and 2 (Sasser's 0 and 1) as resistant and the remainder as susceptible, these backcrosses to known susceptible material gave a population of 365 resistant to 382 susceptible. This yields a Chi-square value of 0.387 for an excellent 1:1 ratio. An F_2 population from some of the above backcrosses gave 117 resistant to 45 susceptible and a Chi-square value of 0.666. All check plants were rated as highly susceptible. It can be concluded that resistance to M. incognita acrita is governed by a single dominant gene.

From one of the above stocks an F_3 line, 54N6, was tested early in 1955 against a population of M. javanica. After 7 weeks the roots of 10 plants were examined. The number of galls ranged from 1 to 17. Egg masses occurred on all plants except the one with one gall. This plant was replanted into infested soil and showed only a few galls after 6 months. Seed from this plant was saved and planted into soil infested with M. javanica. After 7 weeks, 60 plants from line 54N6 showed only a few small galls. Twenty check plants were severely galled.

Seed from this same plant was also planted back into soil infested with M. incognita acrita. After 10 weeks 25 plants were rated 0 or 1 (resistant) and 20 check plants were severely galled.

A single dominant gene appears to govern resistance to M. incognita acrita. While the inheritance of resistance to M. javanica was not investigated, this material was uniformly resistant to both species and was in the F_4 generation beyond the sixth backcross to Lycopersicon esculentum with some intervening selfing at a lower backcross level. The probability that two independent genes were carried together and that both would be homozygous at this level in the 54N6 stock is less than 1 to 360,000. It seems reasonable to consider that a single dominant gene confers a high degree of resistance to both species of nematode. These results confirm in part the results of Winstead and Barham (4).

According to Sasser, Lycopersicon peruvianum is highly resistant to M. incognita and susceptible to all other Meloidogyne species. In this particular L. peruvianum derivative, a high level of resistance is found to both M. javanica and M. incognita acrita. It is evident that L. peruvianum stocks do not all react alike to all the root-knot nematode species, and that the resistant seedstocks in tomato presently available may well possess resistance to M. incognita and three more species.

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THE EFFECT OF ROOT-KNOT NEMATODES, MELOIDOGYNE INCOGNITA ACRITA AND M. HAPLA, ON FUSARIUM WILT OF TOMATO[1]

W. R. Jenkins and B. W. Coursen[2]

Summary

Tomato seedlings were inoculated with Fusarium oxysporum f. lycopersici and either of two species of root-knot nematodes, Meloidogyne hapla or M. incognita acrita. The highly susceptible tomato variety Red Beefsteak wilted in 100 percent of the inoculations when inoculum of Fusarium was present, regardless of whether nematodes were present. The variety Rutgers, which has some resistance to Fusarium, wilted in a shorter time when either species of Meloidogyne was present and the percentage of wilting was increased 40 percent. Chesapeake, a highly resistant tomato, did not wilt except when root-knot nematodes were used in combination with inoculum of Fusarium. When M. incognita acrita was combined with F. oxysporum f. lycopersici, wilting resulted in every inoculation. Only 60 percent wilting was produced when M. hapla was combined with Fusarium. Artificial wounding of roots did not affect the susceptibility of the three tomato varieties tested. The significant role of nematodes appears to amount to more than just providing an entry for the fungus.

INTRODUCTION

In recent years there have been many published reports on the effects of plant-parasitic nematodes on certain fungus and bacterial plant diseases. Some of these have been based on field observations and trials while others have been the result of controlled greenhouse experiments.

Stewart and Schindler (12), working with Meloidogyne spp. and Helicotylenchus nannus Steiner, 1945, showed an increase in the rate of wilting of carnations inoculated with Pseudomonas caryophylli. These authors stated that the significant role of nematodes in the complex involving bacterial wilt of carnation was solely that of providing wounds for entry of the pathogen. No increase in wilting was observed by Lucas and Krusberg (4) in tobacco inoculated with Tylenchorhynchus claytoni Steiner, 1933, and the Granville wilt organism Pseudomonas solanacearum. However, Lucas, Sasser, and Kelman (5) reported that Granville wilt symptoms appeared earlier and to a greater extent when Meloidogyne incognita acrita Chitwood, 1949, was present than when plants were grown in soil infested only with the wilt bacterium. They stated further that the role of nematodes appeared to be principally one of providing wounds for entry of the bacteria.

Holdeman and Graham (3) reported that a susceptible cotton variety showed a greater percentage of Fusarium wilt when the sting nematode, Belonolaimus gracilis Steiner, 1949, was present. A resistant cotton variety wilted only when both organisms were used in combination. They stated that this breakdown of resistance occurred only with B. gracilis, and not when other plant-parasitic nematodes were present and actively feeding on the roots. For this reason, they believed that the effect of the nematode is not merely in damaging the cortex of the root and affording an entry for the pathogenic fungus. In another experiment Holdeman (2) showed that Fusarium wilt of tobacco was more severe when the tobacco stunt nematode, T. claytoni, occurred in combination with the fungus.

Young reported that resistance of tomatoes to wilt caused by Fusarium oxysporum f. lycopersici was decreased in the presence of Heterodera marioni (= Meloidogyne sp.) (13), but in subsequent work (14) he showed that control of the nematode alone did not give control of Fusarium wilt. McClellan and Christie (6) concluded that root-knot nematodes had little effect on the incidence of Fusarium wilt of tomato, squash, and gladiolus.

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[1] Scientific Article No. A606, Contribution No. 2785 of the University of Maryland Agricultural Experiment Station, Department of Botany.

[2] Assistant Professor of Plant Pathology and Graduate Assistant in Plant Pathology, respectively.

Many other authors have shown that control of nematodes often resulted in the control of other diseases also. Among these have been Smith (10, 11), Henry (1), and Morgan (8). On the other hand, McClellan et al. (7) reported that Verticillium wilt of cotton was not controlled when ethylene dibromide was used in nematocidal dosages, although excellent nematode control was obtained.

While examining soils during a nematode survey in Maryland, it was noted that Fusarium wilt of tomato was often associated with heavy infections of root-knot nematodes. In a few instances, mild attacks of Fusarium wilt on the Chesapeake variety of tomato, resistant to Fusarium, were also noted. Each of these latter infections was accompanied by heavy root infection by Meloidogyne incognita acrita. A series of greenhouse experiments was subsequently undertaken to attempt to clarify the relationship of root-knot nematode infections to Fusarium wilt of tomato.

MATERIALS AND METHODS

Nematode inoculum for these experiments consisted of separate cultures of Meloidogyne hapla Chitwood, 1949, and M. incognita acrita Chitwood, 1949, derived from single egg masses. Cultures were maintained in the greenhouse on Maryland bright tobacco. For inoculation, infected roots were cut into small pieces and triturated in a Waring Blendor in a small quantity of water. A tomato seedling was transplanted into a 4-inch pot partially filled with steamed soil and containing about 2 ml. of the nematode-root suspension.

Inoculum of Fusarium oxysporum f. lycopersici was prepared by blending a 1-week-old culture of the fungus in a Waring Blendor. These cultures were maintained on a medium containing 10 g. Bacto peptone, 20 g. sucrose, 0.25 g. magnesium sulfate, 0.5 g. monopotassium phosphate, and 1000 ml. water. Seedlings were inoculated by dipping roots, which had been washed free of soil, into this blended suspension of fungus spores and mycelium. Planting was in steamed soil either in combination with nematodes as described above or without nematodes.

Soil temperature was maintained at a minimum of 27° C through the use of thermostatically controlled lead heating cables buried in sterilized sand. Pots containing tomato plants were buried in this sand up to their rims with guard rows of pots containing steamed soil separating them. All treatments and replications were arranged in a randomized block design.

To test the effect of wounding on the expression of Fusarium wilt, an experiment was designed in which inoculated and uninoculated plant roots were wounded every other day. This wounding was accomplished by stabbing through the soil and root system with a small steel spatula. Several stabs were made in each pot each time. An unwounded and uninoculated check and an unwounded inoculated treatment were also included.

Three horticultural varieties of tomato were used. These were the variety Red Beefsteak which is highly susceptible to Fusarium wilt, Rutgers which has some resistance, and Chesapeake which is highly resistant. All inoculations were made when seedlings were about 6 inches high. Experiments were continued for 5 weeks. Plants which were inoculated with Fusarium, but which were not wilted, were examined for infection as evidenced by vascular browning in the stem, by the presence of the fungus in the stems, or both.

RESULTS

The data from experiments involving nematodes and Fusarium wilt of tomato are presented below and summairized in Table 1.

When plants of the Red Beefsteak variety were inoculated with Fusarium, 100 percent wilting and death resulted (Fig. 1). No difference in time of wilting or death resulted when inoculation with the two species of root-knot nematodes was combined with the Fusarium inoculation. In inoculations with nematodes alone, severe stunting resulted during the test period.

Rutgers tomatoes wilted in only 60 percent of the inoculations with Fusarium alone, taking an average of 22 days to show these symptoms. When M. incognita acrita and M. hapla were used in combinations with Fusarium, wilting was increased in severity so that 100 percent of the plants were affected. In addition, these symptoms appeared in an average of only 17 days, or 5 days faster than with Fusarium alone. Again, severe stunting resulted

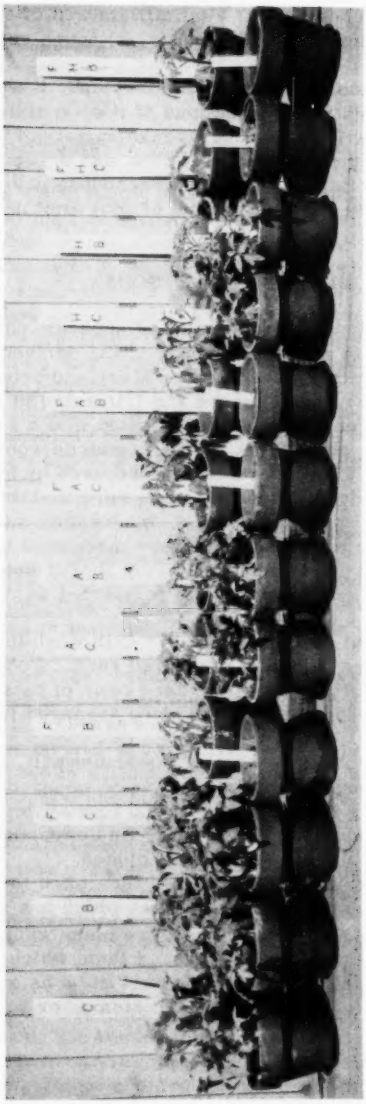

FIGURE 1. Effect of Meloidogyne hapla (H) and M. incognita acrita (A) on the expression of Fusarium oxysporum f. lycopersici (F) in inoculations of tomato varieties Chesapeake (C) and Red Beefsteak (B) three weeks after inoculation.

Table 1. Percentage of wilting and mean days to wilting in three varieties of tomato inoculated with two species of nematodes, Meloidogyne incognita acrita and M. hapla, and with Fusarium oxysporum f. lycopersici.

Treatment	Variety					
	Red Beefsteak		Rutgers		Chesapeake	
	Percent	Days	Percent	Days	Percent	Days
Check	0[a]	0	0	0	0	0
Fusarium	100	15	60	22	0	0
M. incognita acrita + Fusarium	100	15	100	17	100	26
M. hapla + Fusarium	100	15	100	17	60	26

[a] Each figure represents the mean of 3 replications containing 10 plants each.

from inoculations with root-knot nematodes alone.

The variety Chesapeake never showed symptoms of Fusarium wilt when inoculation was made with the fungus alone, nor was there any evidence of infection. When Fusarium plus M. incognita acrita was used, all plants became infected and exhibited wilt symptoms in an average of 26 days. Only 60 percent of the plants inoculated with Fusarium and M. hapla wilted, taking an average of 26 days (Fig. 1). Examination of stems of the remaining, unwilted plants revealed that all were infected. As in the other experiments, inoculations with nematodes alone caused a marked reduction in plant growth.

Following artificial wounding of the roots of plants as described in the preceding section, all Red Beefsteak and Rutgers tomatoes inoculated with Fusarium showed wilting. No difference was noted in time of wilting between wounded and unwounded treatments. No Chesapeake tomatoes wilted in either the wounded or unwounded treatments. Growth was actually increased in plants which were root-wounded and not infected with Fusarium. This effect was probably due to the increased root production following the stabbing and injury of roots.

In another test saprophagous forms of the genera Rhabditis, Cephalobus, and Dorylaimus had no effect on the incidence of wilt; results were similar to those obtained in the absence of nematodes. Trichodorus sp., the stubby-root nematode, is a parasite of tomato (9) but caused no breakdown in resistance of Chesapeake tomatoes in the one experiment in which it was employed.

DISCUSSION AND CONCLUSIONS

The evidence offered here suggests that root-knot nematodes increase the incidence of Fusarium wilt in varieties possessing resistance to this disease, such as Rutgers and Chesapeake. In addition, it appears that nematodes shorten the time necessary for wilt symptoms to appear. In varieties lacking resistance, such as Red Beefsteak, wilting is no more severe nor more rapid in the presence of these nematodes.

Although the wounding provided by the steel spatula was not similar to that caused by nematodes, it did nonetheless provide an entry for the fungus. Wounding was repeated often enough so that a large number of roots were injured over a period of time. The results of this experiment would indicate that in lessening resistance to Fusarium wilt the nematode has a double role, not only providing entry for the fungus, but also causing some host response that lowers the natural resistance. It is therefore concluded that the two species of root-knot nematodes, M. hapla and M. incognita acrita, increase the susceptibility of Rutgers tomatoes and break down resistance in Chesapeake tomatoes.

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OCCURRENCE OF PLANT PARASITIC NEMATODES IN SOIL AND ROOT SAMPLES FROM DECLINING PLANTS IN SEVERAL STATES

A. M. Somerville, Jr., V. H. Young, Jr., and J. L. Carnes[1]

Abstract

Five hundred soil and root samples from boxwood, roses, trees and turf, taken in 21 States, were examined for plant parasitic nematodes. The following genera of nematodes were found: Belonolaimus, Criconemoides, Ditylenchus, Hemicycliophora, Hoplolaimus, Longidorus, Meloidogyne, Paratylenchus, Trichodorus, Tylenchorhynchus, Xiphinema, Pratylenchus, Helicotylenchus, and Rotylenchus. Species of the three last named were observed to be the most frequent and most widespread pests.

Reports of plant parasitic nematode-host relationships for a given State or localized area are numerous. The objective of this paper is to report the nematode findings compiled from samplings made in a number of States on boxwood, roses, trees and turf. The data are from samples taken from declining plants varying in symptoms from extreme chlorosis to poor vigor. Most of the samples were taken by members of our staff and the remainder were submitted to the laboratory by outside agencies.

Nematodes were isolated from the soil by use of a modification of the Baermann funnel technique as described by Christie and Perry (2). To isolate nematodes from plant roots, a Waring Blendor was employed to break the roots into small segments and the resulting debris was transferred to the funnels in the normal procedure. After 48 hours, water was drawn from the funnels and examined for the presence of nematodes.

During recent years, the presence of plant parasitic nematodes on declining boxwoods has been observed on many occasions. The data reported here are from samples taken from Buxus sempervirens and Buxus microphylla. Table 1 shows that the two most frequently encountered nematodes on boxwood were the meadow nematodes (Pratylenchus spp.) and the spiral nematodes (Rotylenchus spp., Helicotylenchus spp.). Sasser (3) has reported that these nematodes are often found associated with declining trees and shrubs.

Commercial rose growers have observed a decline in rose plants which has been attributed to the presence of the dagger (Xiphinema spp.) and meadow nematodes (4). In samples taken from rose plants growing in Connecticut, Florida, Georgia, and New York, these nematodes predominated (Table 2).

The following trees were sampled for plant parasitic nematodes: apple, dogwood, elm, hemlock, magnolia, oak, pine, poplar, and sycamore (Table 3). The nematodes most frequently found were spiral, lance (Hoplolaimus spp.), meadow, stylet (Tylenchorhynchus spp.), and pin (Paratylenchus spp.).

A total of 232 turf samples from 20 States were examined with results given in Table 4. The grasses involved were bent, Bermuda, centipede, fescue, Kentucky bluegrass, rye, St. Augustine and zoysia. The six most prevalent nematodes, listed in order of frequency of occurrence, were stylet, meadow, spiral, lance, dagger, and ring (Criconemoides spp.). Two others of importance on turf in Florida (1), but found less frequently in samples from other States, were the sting (Belonolaimus spp.) and the stubby (Trichodorus spp.) nematodes. The data show that turf samples from the South consistently contained lance nematodes, whereas stylet nematodes occurred consistently in Northern turf samples (6).

It is of interest to note that the spiral, root-knot (Meloidogyne spp.), meadow, stylet, and dagger nematodes were found associated with all four groups sampled (Table 5). The data indicate that the meadow and spiral nematodes are the two generally associated with declining ornamentals and turf.

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Table 1. Plant parasitic nematodes found in boxwood samples.

Nematodes	North Carolina	Tennessee	Virginia	Total	% of samples examined
Number of samples	24	4	182	210	
Belonolaimus	1		4	5	2.4
Criconemoides	2		5	7	3.3
Ditylenchus	1		2	3	1.4
Helicotylenchus and Rotylenchus	12	1	83	96	45.7
Hemicycliophora			3	3	1.4
Hoplolaimus			8	8	3.8
Longidorus			1	1	0.5
Meloidogyne	1		18	19	9.0
Paratylenchus	3		10	13	6.2
Pratylenchus	17		109	126	60.0
Trichodorus	7	2	5	14	6.7
Tylenchorhynchus	3		13	16	7.6
Xiphinema	8	1	10	19	9.0

Table 2. Plant parasitic nematodes found in rose samples.

Nematodes	Connecticut	Florida	Georgia	New York	Total	% of samples examined
Number of samples	18	3	4	2	27	
Helicotylenchus and Rotylenchus	1		1		2	7.4
Meloidogyne		1	1		2	7.4
Pratylenchus	7			2	9	33.3
Tylenchorhynchus			1		1	3.7
Xiphinema	10	1	1	2	14	51.9

Table 3. Plant parasitic nematodes found in tree samples.

Nematodes	Apple	Dogwood	Elm	Hemlock	Magnolia	Oak	Pine	Poplar	Sycamore	Total	% of samples examined
Number of samples	5	4	4	5	3	7	1	1	1	31	
Belonolaimus						1				1	3.2
Criconemoides			1							1	3.2
Ditylenchus			1	1					1	3	9.7
Helicotylenchus and Rotylenchus	3		3	1	1	3			1	12	38.8
Hoplolaimus	1		2	2		4	1		1	11	35.5
Meloidogyne	1									1	3.2
Paratylenchus			3	1		3				7	22.6
Pratylenchus	2		3		1	1			1	8	25.8
Tylenchorhynchus		1	1			3		1	1	7	22.6
Xiphinema		1	1		1					3	9.7

Table 4. Plant parasitic nematodes in turf samples from 20 States.

Nematodes	Arizona	California	Colorado	Connecticut	Florida	Georgia	Illinois	Louisiana	Maryland	Massachusetts	Michigan	New Hampshire	New Jersey	New York	North Carolina	Oklahoma	South Carolina	Texas	Virginia	West Virginia	Total	% of samples examined
Number of samples	6	3	4	4	29	9	1	1	21	29	15	1	11	6	25	2	7	26	30	2	232	
Belonolaimus				1	9	1									3						14	6.0
Criconemoides		1	1		11	3		1		1			1		4						23	9.9
Ditylenchus				1	2	1			1		1				2				1		9	3.9
Helicotylenchus and Rotylenchus	1	2	2		9	4	1		3	5	2		3	4	16		3	9	12	1	77	33.2
Hemicycliophora					1										1						2	0.9
Hoplolaimus				2	13	3			3	1	2		4	1	8		1	5	6	2	51	22.0
Longidorus									1												1	0.4
Meloidogyne					4				3		1				1		1		1		11	4.7
Paratylenchus					1	1			2				4	4					1		13	5.6
Pratylenchus	1	2	1	2	10	2	1		8	5	5		7	4	11		2	1	17		79	34.1
Trichodorus				1	5	1		1							3		1	1	3		16	6.9
Tylenchorhynchus	2	2	2	4	6				4	25	4	1	4	4	5		3	8	12		86	37.1
Xiphinema				1	5	4				5				1	2		2	2	5		27	11.6

Table 5. Plant parasitic nematodes found with 4 plant types.

Nematodes	Boxwood	Roses	Trees	Turf	Total	% of samples examined
Number of samples	210	27	31	232	500	
Belonolaimus	5		1	14	20	4.0
Criconemoides	7		1	23	31	6.2
Ditylenchus	3		3	9	15	3.0
Helicotylenchus and Rotylenchus	96	2	12	77	187	37.4
Hemicycliophora	3			2	5	1.0
Hoplolaimus	8		11	51	70	14.0
Longidorus	1			1	2	0.4
Meloidogyne	19	2	1	11	33	6.6
Paratylenchus	13		7	13	33	6.6
Pratylenchus	126	9	8	79	222	44.4
Trichodorus	14			16	30	6.0
Tylenchorhynchus	16	1	7	86	110	22.0
Xiphinema	19	14	3	27	63	12.6

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CHEAP, DISPOSABLE FILTERS FOR NEMATODE SURVEYS

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For surveys of nematode populations, a simple and rapid filtration technique has been developed that eliminates the cumbersome and time-consuming use of Baermann funnels and is simpler than the method of Anderson and Yanagihara (1). Filters are simply constructed of 5-ounce paper cups and Scotties (a paper facial tissue manufactured by Scott Paper Co. having high wet strength). The bottom is cut out of the paper cup, leaving the rim for strength. Scotties are cut into thirds and each portion is folded into thirds to make a filter pad. The pad is then pressed snugly over the bottom of the paper cup with the lower section of a 55-mm Petri dish and is snugly fastened in place with a rubber band. On removal of the Petri dish, the filter is ready for use. Such filters can be assembled in about a minute.

Soil samples may be placed directly into these filters, or the residue on a screen may be washed into them. In the latter case the filter may be supported on a screen or sponge while the water drains away. Then the filter is placed in a paper cup containing 15 ml of water. The nematodes will work through the tissues into this water after 24 to 96 hours. The filter containing the soil and plant residue can then be thrown away, leaving the nematodes in the paper cup. Roots may be soaked directly in these filters by increasing the amount of water to cover the roots.

There are many advantages to such filters. The Scotties permit passage of only a small amount of even the finest silts and as a result the water containing the nematodes is very clean. Soil may be put directly into the cups without screening or settling to remove the fine sediment. The Scotties are very strong even when wet. Not one has broken while being removed from the paper cup, even though the filter sometimes was almost full of water or mud. Each sample stands alone, requiring no rack. When the filter is discarded, more water may be added to the cups and these stored, for months if necessary, in a cooler until examined. Samples have been stored for 4 months at 2° C without harming the nematodes. Water was added once to the paper cup to replace that lost by evaporation. The filters are inexpensive to use as a paper cup costs less than 1 cent, and the cost per filter, including cost of assembly, might be about 4 cents.

These filters have proven more efficient for recovery of nematodes from soil samples than other filters in standard use.

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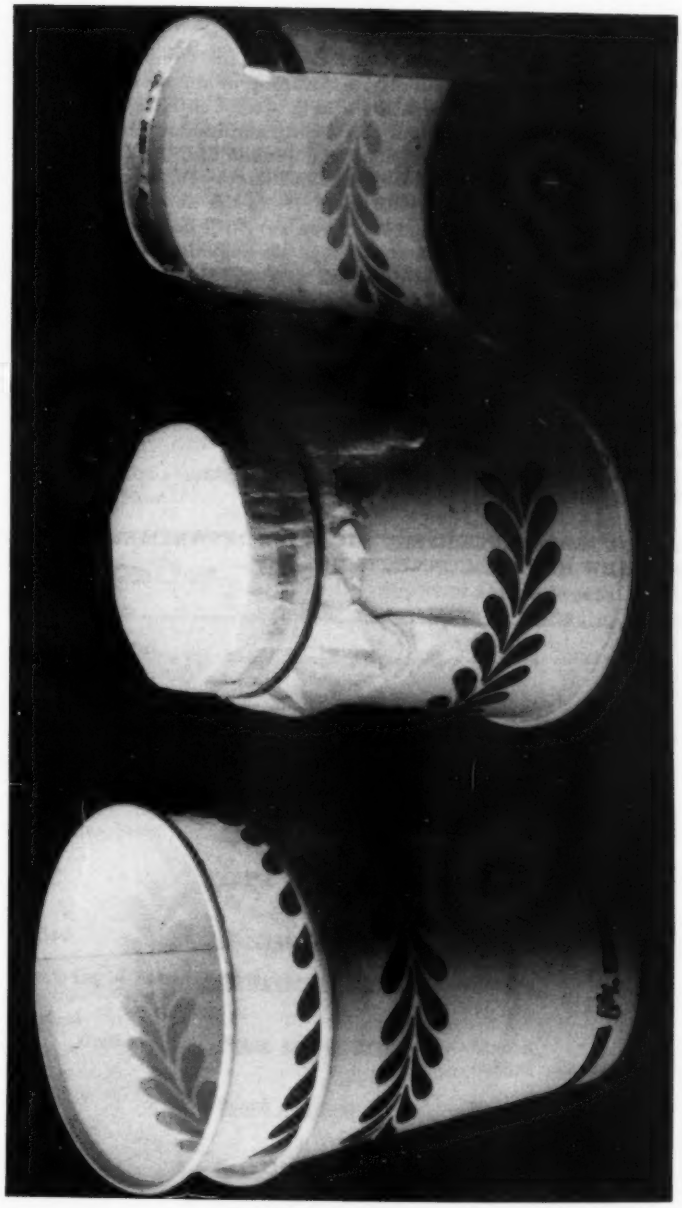

FIGURE 1. At left the filter is in place over water in paper cup. In the center is an inverted filter with Scottie tissues retained by rubber band. At the right is a cross-section view of filter without tissues showing rim left by removal of bottom. This rim prevents crumpling of cup by the rubber band.

A METHOD FOR THE QUICK SEPARATION OF NEMATODES FROM SOIL SAMPLES

Patrick M. Miller

A modification of the centrifugal-flotation method of Caveness and Jensen (1) has speeded separation of nematodes from soil samples and permits examining nematodes in 15 to 20 minutes after receipt of the soil sample. The deviation starts after centrifuging the sample in sugar solution. Instead of pouring the supernatant containing nematodes into water and allowing them to settle for at least an hour, as Caveness and Jensen did, it is instead poured on to a 325-mesh screen. The sugar solution goes on through the screen, taking with it any suspended colloidal soil particles but leaving the great majority of the nematodes on the screen. The nematodes are rinsed and then washed from the screen into a Syracuse watch glass for examination. When the soil is sandy and contains little organic matter, the first centrifuging with water may be eliminated. In this case the nematodes can be examined in the Syracuse dish about 10 minutes after receipt of the soil sample.

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TOLERANCE OF PLANTS TO V-C 13 NEMACIDE

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V-C 13 Nemacide[2], an emulsifiable concentrate containing 75% of O-2, 4-dichlorophenyl O, O-diethyl phosphorothioate, has been employed for the control of soil nematodes attacking living plants for the past three years. It is the purpose of this paper to present data on the tolerances of treated plants or plant seeds to various concentration levels of V-C 13 Nemacide. The nematocidal activity data of these treatments will not be reported here.

Treatments have been made to plants in the following categories: ornamentals, including annuals, bulbs and ground covers (Table 1); trees and berries (Table 2); grasses (Table 3); and field and truck crops (Table 4). The scientific names of plants given in Tables, 1, 2, and 4 are from the "Manual of Cultivated Plants" by L. H. Bailey, published in 1949 by The Macmillan Company, and those in Table 3 are from the "Manual of the Grasses of the United States" by A. S. Hitchcock, Miscellaneous Publication No. 200, USDA, 1950.

The concentration of V-C 13 per acre given for each plant is not necessarily the one recommended for nematode control. In a number of instances extremely high concentrations of V-C 13 were employed for the sole purpose of determining upper tolerance levels.

The presentation of data pertaining to the tolerances of edible crops to V-C 13 does not imply that the use of this material is being recommended for these crops at this time. All such data has been obtained under exploratory or experimental conditions.

Table 1. Ornamentals (including annuals, bulbs and ground cover) tolerant to V-C 13 Nemacide.

Plant Name		Age or Growth Stage	Gallons V-C 13 per acre	Application Method
Common	Scientific			
African Violet	*Saintpaulia ionanthus*	Rooted Cuttings	27	Foliar Drench[b] Soil Drench[c] Soil Mix[d]
Aralia	*Polyscias balfouriana*	Mature	27	Soil Drench
Ardisia	*Ardisia crispa*	Mature	27	Soil Drench
Asparagus Fern	*Asparagus plumosus*	Mature	54	Soil Drench
Aster	*Aster* sp.	------	30	Soil Mix[g]
Azalea	*Rhododendron* sp.	Liners[a]	54	Soil Drench
Bowstring - Hemp	*Sanseviera zeylanica*	Mature	27	Soil Drench
Boxwood				
Common	*Buxus sempervirens*	Liners	100	Soil Drench
		Mature plants	200	Soil Needle[e]
	Buxus microphylla	Rooted Cuttings	27	Soil Drench[h]
		Mature	54	Soil Needle
Camellia	*Camellia japonica*	Liners	54	Soil Drench
	Camellia Sasanqua	Rooted Cuttings	27	Soil Drench[h]

[1] Research and Development Department, Virginia-Carolina Chemical Corporation, Richmond, Virginia.

[2] A product of Virginia-Carolina Chemical Corporation, Richmond, Virginia.

Table 1 Continued.

Plant Name		Age or Growth Stage	Gallons V-C 13 per acre	Application Method
Common	Scientific			
Candy Tuft	Iberis sp.	------	30	Soil Mix[g]
Carnation	Dianthus Caryophyllus	Pre-bloom	27	Soil Drench
Chrysanthemum	Chrysanthemum sp.	Rooted Cuttings	54	Soil Drench
Coleus	Coleus Blumei	Rooted Cuttings	54	Soil Drench
Cosmos	Cosmos sp.	------	30	Soil Mix[g]
Cranesbill (Geranium)	Geranium sp.	Rooted Cuttings	54	Soil Drench
Daisy	Bellis sp.	Pre-bloom	27	Soil Drench[i]
Feijoa	Feijoa sellowiana	Mature	27	Soil Drench
Firethorn	Pyracantha sp.	Liners	54	Soil Drench
Gardenia	Gardenia jasminoides	Liners Mature	27	Soil Drench
Holly Japanese	Ilex crenata var.	Liners Mature	54	Soil Drench
Chinese	Ilex cornuta	Liners	54	Soil Drench
Ivy - Arum (Pothos)	Scindapsus aureus	Rooted Cuttings Mature	27	Soil Drench
Ixora	Ixora coccinea	Mature	27	Soil Drench
Larkspur	Delphinium sp.	-----	30	Soil Mix[g]
Marigold	Tagetes sp.	-----	30	Soil Mix[g]
Nasturtium	Tropaeolum sp.	-----	30	Soil Mix[g]
Osmanthus	Osmanthus fragrans	Liner	27	Soil Drench
	Osmanthus sp.	Mature	27	Soil Drench
Pansy	Viola tricolor	Pre-bloom	54	Soil Drench
Parlor Palm	Collinia elegans	Mature	27	Soil Drench
Peony	Paeonia sp.	Pre-bloom	27	Soil Drench
Peperomia	Peperomia sp.	Rooted Cuttings	54	Soil Drench
Philodendron	Philodendron cordatum	Mature	27	Soil Drench
Photinia	Photinia sp.	Mature	27	Soil Drench
Podocarpus	Podocarpus macrophylla	Mature	27	Soil Drench
Poinsettia	Euphorbia pulcherrina	Mature	54	Soil Drench

Table 1 Continued.

Plant Name		Age or Growth Stage	Gallons V-C 13 per acre	Application Method
Common	Scientific			
Prickly - Pear	Opuntia sp.	Mature	54	Soil Drench
Princess Flower (Glory-Bush)	Tibouchina sp.	Mature	27	Soil Drench
Privet	Ligustrum lucidum	Liners Mature	54	Soil Drench
	Ligustrum japonicum		54	Soil Drench
Rose	Rosa sp.	Pre-bloom	54	Soil Drench
Rose - Mallow	Hibiscus sp.	Mature	27	Soil Drench
Snapdragon	Antirrhinum majus	Pre-bloom	27	Soil Drench[i]
Sunflower	Helianthus sp.	-----	30	Soil Mix[g]
Sweet Pea	Lathyrus odoratus	-----	30	Soil Mix[g]
Yew	Taxus sp.	Mature	27	Soil Drench
Zinnia	Zinnia sp.	-----	30	Soil Mix[g]
Caladium	Caladium bicolor	-----	54	Soil Drench[k]
		Bulbs (Dormant)	2% Sol. V-C 13	One Hour Dip[l]
		Mature	15	Soil Drench
Cyclamen	Cyclamen sp.	Blooming	54	Soil Drench
Dahlia	Dahlia sp.	Pre-bloom	27	Soil Drench
Gladiolus	Gladiolus sp.	-----	27	Soil Mix[m]
Iris	Iris Xiphium	-----	24	Soil Mix[k]
		Bulbs	5% sol. V-C 13	One hour dip[n]
	Iris sp.	Mature	27	Soil Drench
Lily	Lilium sp.	-----	27	Soil Mix[m]
Narcissus	Narcissus sp.	-----	24	Soil Mix[k]
		Bulbs	5% sol. V-C 13	One hour dip[n]
Tulip	Tulipa sp.	Bulbs	27 1% sol. V-C 13	Soil Mix One hour dip[n]

Table 1 Concluded.

Plant Name		Age or Growth Stage	Gallons V-C 13 per acre	Application Method
Common	Scientific			
Dichondra	Dichondra repens	----	28	Soil Drench [o]
		Seedling	28	Soil Drench [p]
Periwinkle	Vinca minor	Mature	27	Soil Drench

[a] Liners (Lining Out Stock) = Immature plants placed out in field for development before being placed in permanent growing area.

[b] Foliar Drench = V-C 13 solution sprayed or poured on foliage, and allowed to run off to the soil.

[c] Soil Drench = V-C 13 solution sprayed or poured on soil surface.

[d] Soil Mix = V-C 13 solution sprayed or poured on soil surface, followed by discing or roto-tilling of treated soil.

[e] Soil Needle = V-C 13 solution applied sub-soil by means of needle injector working under hydraulic pressure.

[f] Net contents per gallon = 10 lbs. of 75% emulsifiable concentrate.

[g] Seeds planted minimum 2 weeks following soil application - Germination normal.

[h] Planted 14 days following soil treatment.

[i] Plants also transplanted into drenched soil two weeks following application.

[k] Bulbs planted immediately following soil application.

[l] Bulbs planted immediately into drenched soil (54 gals/a).

[m] Bulbs planted minimum2 weeks following soil application.

[n] Bulbs planted in untreated soil.

[o] Seeds planted one day following soil treatment.

[p] Treatment made three days following emergence of seedling.

Table 2. Trees and berries tolerant to V-C 13 Nemacide.

Plant Name		Age or Growth Stage	Gallons V-C 13 per acre	Application Method
Common	Scientific			
Apple	Malus sp.	Seedlings	27	Soil Drench
Fig	Ficus sp.	Mature	27	Soil Drench
Hemlock	Tsuga sp.	Mature	27	Soil Drench
Maple	Acer sp.	Seedling	27	Soil Drench
Oak	Quercus sp.	Mature	54	Soil Needle
Peach	Prunus persica	Mature	100	Soil Drench
Pine	Pinus sp.	Seedling	27	Soil Drench
Sweet Orange	Citrus sinensis	Mature	90	Soil Needle
	Citrus limon or		30	Soil Drench
	Citrus aurantium		15	Irrigation
Blueberry	Vaccinium sp.	Mature	54	Soil Drench

Table 3. Grasses tolerant to V-C 13 Nemacide[a].

Plant Name		Age or Growth Stage	Gallons V-C 13 per acre	Application Method
Common	Scientific			
Bent Grass				
Creeping Bent (Seaside)	Agrostis palustris	Mature	27	Soil Drench
Colonial Bent	Agrostis tenuis	Mature	15	Soil Drench
Bermuda Grass	Cynodon dactylon	Mature	27	Soil Drench
Centipede Grass	Eremochloa ophiuroides	Mature	27	Soil Drench
Chewings Fescue	Festuca rubra var. commutata	Mature	27	Soil Drench
Kentucky Bluegrass	Poa pratensis	Mature	27	Soil Drench
Redtop Grass	Agrostis alba	Mature	27	Soil Drench
Ryegrass				
Italian	Lolium multiflorum	Mature	27	Soil Drench
Perennial	Lolium perenne	Mature	27	Soil Drench
St. Augustine Grass	Stenotaphrum secundatum	Mature	27	Soil Drench
Zoysia Grass	Zoysia sp.	Mature	27	Soil Drench

[a] General Remarks: All grass seeds planted in newly V-C 13 treated soils will demonstrate temporary retarded germination. At times, some of the treated grasses will demonstrate temporary discoloration.

Table 4. Field and truck crops tolerant to V-C 13 Nemacide.

Plant Name		Age or Growth Stage	Gallons V-C 13 per acre	Application Method
Common	Scientific			
Carrot	Daucus Carota	-----	20	Soil Mix [a]
Celery	Apium graveolens	Transplant	27	Soil mix[b]
Corn	Lea Mays	-----	20	Soil Mix [a]
Cucumber	Cucumis sativus	-----	20	Soil Mix [a]
Eggplant	Solanum Melongena	Transplant	14	Plow-Sole Injection [b]
Kidney Bean (Bush)	Phaseolus vulgaris	-----	20	Soil Mix [a]
Peanut	Arachis hypogaea	-----	20	Soil Mix [a]
Pepper	Capsicum frutescens	Transplant	30	Soil Mix [b]
Potato	Solanium tuberosum	-----	30	Soil Mix [a]
Squash	Cucurbita Pepo var Melopepo	-----	20	Soil Mix [a]
Tobacco	Nicotiana Tabacum	Transplant	20	Soil Mix [b]
Tomato	Lycopersicon esculentum	Transplant	30	Soil Mix [b]

[a] Seeds planted minimum 2 weeks following soil application.

[b] Transplanting conducted 2 weeks following soil application.

VIRGINIA-CAROLINA CHEMICAL CORPORATION, RICHMOND, VIRGINIA

SHORT NOTES ON NEMATODE OCCURRENCE

SOYBEAN CYST NEMATODE IN MISSOURI

By A. H. Hegge[1]

Shortly after the discovery of the soybean cyst nematode, Heterodera glycines Ichinohe, in western Tennessee, steps were taken to determine if the pest was present in southeastern Missouri.

On December 5, 1956, soil collections for soybean cyst nematode examination were taken from six fields in Pemiscott County, Missouri by Virgil Owens, Assistant State Entomologist in Missouri, A. H. Hagge of the Plant Pest Control Branch and others. Soil was collected from six soybean stubble fields located across the Mississippi River from the Lake County, Tennessee infestation. Examination revealed the presence of numerous lemon-shaped cysts in one of the six soil collections. The cysts later were positively identified as those of the soybean cyst nematode.

During the week of December 17, soil collections were taken from 41 other fields planted to soybeans in 1956 in Pemiscott County. Examination of the soil revealed the presence of the soybean cyst nematode in eight of these fields, bringing the known total infested locations in Missouri to nine.

The nine fields are all within one to five miles of the Mississippi River. The fields extend from a point 3 miles north of the Missouri-Arkansas line to a point 18 miles farther north. The extent of the infestation has not been determined; however there is little doubt but what there are other fields infested in the locality. A laboratory to wash soil samples to examine flotsam for cysts of this nematode has been established at Hayti, Missouri by State Entomologist Julius Anderson and his assistants. Surveys are currently being conducted by State and Federal personnel to determine the extent of the infestation in Pemiscott County and the possible presence of the pest in other Missouri counties.

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SUGAR BEET NEMATODE FOUND IN THE ONTARIO-NYSSA AREA OF OREGON

By Harold J. Jensen, Lindsay B. Loring, and Jared Lewis[1]

In 1955 we reported (Plant Dis. Reptr. 40: 406, 1955) that the sugar beet nematode, Heterodera schachtii, Schmidt, 1871, was present in the Milton-Freewater area. This is the smaller of the two major areas producing sugar beets in Oregon. During September, 1956, the nematode was discovered in a 10-acre field near Ontario, the larger area, some 200 miles southeast of Milton-Freewater. Subsequent surveys of adjacent fields and of harvested beets at central dumping grounds have revealed three additional infested fields in the Ontario-Nyssa area. Up to this time the approximately 4500 acres in Oregon and adjacent portions of Idaho had been considered the last major production area free of the pest in this country. Every precaution is being taken to prevent spread of the sugar beet nematode in this new area.

OREGON AGRICULTURAL EXPERIMENT STATION, OREGON DEPARTMENT OF AGRICULTURE, AND AMALGAMATED SUGAR COMPANY

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CONTROL OF LOOSE SMUT OF BARLEY BY WATER-SOAK AND ANAEROBIC TREATMENTS[1]

I. N. Tandon and E. D. Hansing[2]

Abstract

The anaerobic treatment was more satisfactory than the water-soak in controlling loose smut of barley because it controlled smut and only slightly reduced emergence. The length of both treatments necessary to control smut was related inversely to temperature. The most effective anaerobic treatment consisted of holding soaked seed (soaked for 2 hours in water) in an air tight container at 80° F for 48 hours. Smut was controlled and emergence not reduced significantly.

In 1951 Tyner (6) reported control of loose smut of barley (Ustilago nuda (Jens.) Rostr.) by soaking infected seed for 6 hours in water and then immersing it in 0.2 percent suspension of Spergon SL (tetrachloro-parabenzoquinone) for 40 hours at room temperature (72° F). In 1953 he reported (7) that soaking in water alone for 56 to 64 hours also controlled smut effectively. Arny and Leben (1, 2) and Russell and Tyner (5) also obtained control of smut by water-soak as well as Spergon treatments, but both treatments reduced emergence. Reduction was greater for the Spergon treatment.

Hebert (3, 4) controlled loose smut of barley by holding soaked seed in air tight containers. He reported that the treatment did not appreciably reduce germination.

An experiment was conducted in the spring of 1956 to study effects of temperature and length of time for the anaerobic treatment compared with the water-soak treatment. The object of this investigation was to compare the two treatments in regard to their effectiveness in controlling smut as well as their effect on the germination of the seed.

MATERIALS AND METHODS

The experiment was conducted with two naturally-infected seed samples of Beecher barley obtained from Republic and Riley Counties. In the water-soak treatments 120 ml of seed by volume were soaked in 300 ml of distilled water in pint jars. For the anaerobic treatment, 240 ml of seed were soaked in water at room temperature (70-75° F) two hours, drained, and then held in air tight pint jars. The seed occupied approximately half the volume of the jars. The treatments varied in number of hours as follows with the exception of a 2-hour pre-soak period for the anaerobic treatment: at 70° (±2), 48, 60, and 72; at 80° (±2), 24, 36, and 48; and at 90° (±2), 12, 24, and 36.

After treating, the seed was dried at room temperature (70-80° F) and a week later planted in the field. Planting was done in 5 replicated 12-foot rows and the treatments within a replication were randomized. Each row was planted with 200 seeds. Planting was done March 10, 1956, and the number of seedlings counted a month later. The number of smutted heads was counted May 27. Data were analyzed statistically and the least significant differences calculated at the five percent level. The L.S.D. technique was followed for comparing the value of means.

RESULTS

Loose smut was reduced by all anaerobic and water-soak treatments in this experiment (Table 1). The temperature and duration of the treatments were important and control of smut improved with an increase in temperature as well as with an increase in the length of treatment. Complete control of smut was obtained by both treatments carried out at 80° and 90° F for 48 and 24 hours, respectively. The emergence of seedlings after the water-soak

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Table 1. Effect of temperature and the length of treatment on the anaerobic treatment as compared with the water-soak treatment on the emergence and control of loose smut of Beecher spring barley, 1956.

Temperature °F	Length of treatment in hours	Republic County				Riely County			
		Percentage				Percentage			
		Emergence		Smutted heads		Emergence		Smutted heads	
		Treatment				Treatment			
		Anaerobic	Water-soak	Anaerobic	Water-soak	Anaerobic	Water-soak	Anaerobic	Water-soak
70	Low (48)	76 *	66	6 *	1	73 *	57	2	1
70	Medium (60)	67 *	62 *	3 *	0	65 *	58 *	2	T[a]
70	High (72)	67 *	51	1	0	66 *	35	T	0
80	Low (24)	77 *	72 *	5	4 *	70	67	3 *	3 *
80	Medium (36)	72 *	64 *	5 *	0	69	67 *	0	T
80	High (48)	71 *	41	0	0	66 *	49	0	0
90	Low (12)	70	73 *	6 *	4 *	70	72 *	2	3
90	Medium (24)	71	68 *	1	T	70 *	65 *	0	1
90	High (36)	70 *	10	0	0	62 *	28	0	0
No treatment		74		16		68		9	
L.S.D. at 5 percent		4.5		2.5		5.9		2.1	

* Indicates that the values on either side differ significantly at5 percent from each other.

[a] T indicates 0.1 to 0.5 percent of smutted heads.

treatments, however, was much lower than for the anaerobic treatments. The anaerobic treatments controlled smut with less reduction in emergence than the water-soak treatments.

Furthermore, it was easier to dry the seed treated by the anaerobic method than grain soaked for long periods in water. The containers, however, have to be air tight with no leakage. The anaerobic treatment carried out at 80° F for 48 hours was the best since it controlled smut completely with the least reduction of emergence. This method may be used to reduce losses from brown loose smut of barley.

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CHEMICAL CONTROL OF MELTING-OUT OF KENTUCKY BLUEGRASS[1, 2]

Houston B. Couch and Herbert Cole, Jr.[3]

Summary

Melting-out of Kentucky bluegrass and Helminthosporium blight of Illahee fescue, caused by Helminthosporium vagans Drechsl. and H. dictyoides Drechsl. respectively, were epiphytotic in Pennsylvania during the 1956 growing season. Complete loss of stands was common, and in many areas, plantings were rendered so undesirable it was necessary that they be re-established.

In replicated field tests, Acti-dione, Kromad, Omadine, Captan 50-W, and Terramycin gave highly signifcant reductions in intensity of the leaf spot phase of the disease of Kentucky bluegrass. Yield tests showed Acti-dione, at 1200 mg per 1000 square feet, to cause a temporary reduction in growth of Kentucky bluegrass, while Omadine, Kromad, and Captan 50-W brought about significant increases in yield per plot.

None of the materials tested gave satisfactory control of Helminthosporium blight of Illahee fescue. Terraclor, at 4 ounces per 1000 square feet, was extremely phytotoxic on this species, killing approximately 50 percent of the plants in the test areas.

The 1956 growing season in Pennsylvania was marked by severe outbreaks of melting out of Kentucky bluegrass (Poa pratensis L.) and Helminthosporium blight of fescues (Festuca spp.), caused by Helminthosporium vagans Drechsl. and H. dictyoides Drechsl. respectively. The prolongation of cool, wet weather was conducive to the development of the leaf spot phase of these diseases in epiphytotic proportions through the month of July. The balance of the summer was characterized by sporadic outbreaks in various sections of the State. At the peak of disease development, many stands of Kentucky bluegrass were either entirely killed, or rendered so undesirable it was necessary that they be re-established.

Regarding chemical control of melting-out of Kentucky bluegrass, Monteith (3) suggested that Bordeaux mixture might check the disease, but stated that he knew of no report of it having been used. Horsfall (2) reported that a 7.2% copper-lime dust inhibited spore germination of H. vagans, but did not try the material on a field scale.

Working with the Helminthosporium complex of turf grasses in general, Vaughn and Klomparens (4) stated that while phenyl mercury did not give satisfactory control, Acti-dione completely checked the diseases.

In the present investigation, Acti-dione (cycloheximide), Kromad (5% cadmium sebacate, 5% potassium chromate, 1% malachite green, 0.5% auramine, and 16% tetramethylthiuram disulfide), Omadine (the disulfide derivative of 2-pyridinethione 1-oxide, 50%), Captan 50-W (50% N-(trichloromethylthio)-4-cyclohexene-1-2-dicarboximide), and Terramycin (oxytetracycline) were tested for control of melting out of Kentucky bluegrass (Table 1).

Each compound was tested at 2 rates on 2 dates of application for a total of 21 treatments randomized through 6 replications (Table 1). Each plot measured 4 feet x 25 feet. Materials were applied under 35 pounds pressure, using a boom-type, T-jet system, held 18 inches above the turf. All applications were made on the basis of dilution in 1.25 gallons of water per 1000 square feet.

Triton B-1956 wetter and sticker was used with each treatment at 2 ounces per 50 gallons of water.

The test area consisted of a third-year stand of Kentucky bluegrass. At the beginning of the investigation the plants were heavily infected with H. vagans and disease incidence was uniform throughout the area.

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[2] This work was supported in part by funds from the Turf Research Foundation.

[3] Assistant Professor of Plant Pathology and Research Assistant respectively.

Table 1. Relative effectiveness of the 5 fungicides in the control of melting out of Kentucky bluegrass.

Fungicide	Date application[a,b]	Rate of application per 1000 sq. ft.	Disease rating	Ave. yield per plot (gms. dry wt.)
Check	0	0	1.8	96
Omadine	a	100 gm.	1.7	103
	a+b	100 gm.	1.1	105*
	a	200 gm.	1.3	103
	a+b	200 gm.	0.8	109**
Kromad	a	2 oz.	1.2	104
	a+b	2 oz.	1.2	107*
	a	4 oz.	1.2	93
	a+b	4 oz.	0.9	113**
Acti-dione	a	600 mg.	1.1	98
	a+b	600 mg.	1.0	95
	a	1200 mg.	1.1	94
	a+b	1200 mg.	0.8	85*
Terramycin	a	600 mg.	1.2	96
	a+b	600 mg.	1.2	99
	a	1200 mg.	1.3	102
	a+b	1200 mg.	1.1	96
Captan 50-W	a	2 oz.	1.2	103
	a+b	2 oz.	1.1	97
	a	4 oz.	1.3	101
	a+b	4 oz.	1.0	108**
L.S.D.	.05		0.3	9
	.01		0.4	112
	.001		0.5	

[a] = May 22, [b] = June 1.

Disease incidence and severity ratings were made 12 days after the second date of fungicide application. Sampling of each plot for leaf infection readings was accomplished in the following manner: A 15-foot grid system of twine, providing 15 1-foot square sections arranged in a linear fashion, was stretched over the center of each plot in such a manner as to orient the long axis with that of the area to be sampled. For each plot, 5 of the 1-foot sections were selected at random and 20 leaves taken from each. Using an infection scale reading from 1-5, based on percentage of leaf area covered by lesions, each 20-leaf sample was rated. The total 100-leaf rating for the plot was then computed by averaging the 5 samples.

A further test of the efficiency of the compounds used was made by taking samples for yield comparisons simultaneously with the leaf spot collections. This was accomplished by collecting all of the clippings from a 16-inch swath cut with a hand lawn mower through the center, and for the full length, of each plot. Final readings on these samples were taken after they had been dried to a constant weight at 40° C. These results, as well as the leaf lesion ratings, were subjected to analysis of variance.

With the exception of the lowest dosage and single application of Omadine, all of the materials tested gave a reduction in incidence of leaf lesions significant from the check at the 0.1 percent level. In addition, highly significant increases in yields per plot were ob-

tained with two applications of Omadine, Kromad, and Captan 50-W at 200 gm., 4 ounces, and 4 ounces respectively (Table 1). The level of disease control afforded by these three treatments was readily apparent. These plots were considerably greener and the plants much taller than the checks as well as the other treated areas.

Acti-dione, at 1200 mg. per 1000 square feet, brought about a significant reduction in growth of Kentucky bluegrass (Table 1). This retartadive influence lasted about 7 days. The chlorotic flecking of the lamina characteristic of this material on the Merion variety of Kentucky bluegrass (1) was not observed.

A similar trial was conducted simultaneously for control of Helminthosporium blight of Illahee fescue (Festuca rubra L.). In this series, Acti-dione, Kromad, and Captan 50-W were tested at the above-mentioned rates, while the disulfide form of Omadine was replaced with the 50% zinc salt of this material at 100 gm. and 200 gm. per 1000 square feet, and Terraclor (pentachloronitrobenzene, 75% wettable powder), at 2 ounces and 4 ounces per 1000 square feet, was substituted for Terramycin.

Disease incidence ratings were made 12 days after the second date of fungicide application. Analysis of the readings did not reveal a significant decrease in incidence of leaf lesions nor increase in yield per plot for any of the materials tested. Terraclor, at 4 ounces per 1000 square feet, was extremely phytotoxic to Illahee fescue. The toxic effect of this compound, manifested as a slight retardation in growth followed by an overall withering of the leaves, was evident 5 to 7 days after treatment, with approximately 50 percent of the plants in the plots being killed.

The reaction of H. vagans and H. dictyoides in culture to the fungicides used in the field trials was investigated. Using potato dextrose-yeast agar, the two organisms were grown in 5 concentrations of each material, ranging from 0.01 μg. per ml. to 1 mg. per ml., at 20° to 23° C. Mean diameter growth of the cultures was used as the criterion for comparison.

Helminthosporium vagans was much more sensitive than H. dictyoides to the varying concentrations of Captan 50-W, while the latter species showed far less tolerance to Terraclor and the zinc salt of Omadine. No difference in response of the two species to the other fungicides was noted.

DISCUSSION

The primary economic aspect of the leaf lesion phase of melting out of Kentucky bluegrass is leaf abscission. Infection is generally heavier at the base of the leaf sheath, and since one lesion located in this area can result in the loss of the entire leaf, the level of protection provided by a fungicide must be extremely high if economic control of the disease is to be realized. This is borne out by the fact that although almost all of the treatments gave highly significant reductions in lesion incidence, only Kromad, Captan, and Omadine, applied at 10-day intervals, reduced leaf abscission to the extent that it could be measured in increased yield per plot.

It is the writers opinion that in evaluating the level of chemical control of melting out of Kentucky bluegrass in large scale field tests, the yield sampling technique described herein is much simpler and provides a more accurate picture of response to treatment than a leaf lesion incidence rating system, and can be used to the exclusion of the latter approach.

It is felt that the negative results in control of Helminthosporium blight of Illahee fescue could have been due to the low amount of diluent used. This species is characterized by a rather heavy mat-type of growth, and it is possible that the materials were not placed in the critical areas, i.e. crowns and bases of leaf sheaths.

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SPRAYING WITH COPPER OXYCHLORIDE SULFATE FOR THE CONTROL OF BLACK SPOT AND POWDERY MILDEW OF ROSES[1]

H. R. Rosen

The notes here presented are based wholly on the writer's observations at the Tulsa, Oklahoma, Municipal Rose Garden made in early October, 1956. This beautiful garden of about 15,000 plants suffered seriously during the past 2 years from late spring frosts and freezes, including the March freezes described in The Plant Disease Reporter 40: 30-32, 1956. Likewise, during the current season it has gone through exceptionally severe drought and hot weather periods during most of the summer and fall.

Despite these vicissitudes, the garden presented a most inspiring spectacle this fall. True, many of the varieties were far below normal in number, size and color of bloom but there were enough present in most varieties to offer a joyous array of beauty, and some varieties like Fashion, Montezuma, Spartan, and the old Christopher Stone acted as if nothing extraordinary had happened. They were full of bloom.

The beds were heavily mulched with ground tree leaves, the mulch being 2 to 3 inches thick, and were watered on the average of once every other day throughout most of the summer and fall. The watering was by overhead sprinkling and was continuous throughout the day and sometimes through the night.

With that much overhead watering and with so many plants present, one would expect to find much black spot (Diplocarpon rosae) in this section of our country, and private gardens around Tulsa as well as in Arkansas had their full quota of this disease. To my amazement, I was unable to find a single black spot lesion in this whole garden.

Of the 2 to 3 hours spent in this garden as much or more time was spent looking for black spot and for powdery mildew (Sphaerotheca sp.) as for observation of flowers. I just couldn't "believe my eyes". In a region where black spot is usually rampant, seemingly irrespective of measures used for control of this disease, there were no signs or symptoms to be seen, and no powdery mildew.

Better still, notwithstanding the almost constant overhead watering necessitated by the prolonged drought and heat, and the commonly observed phenomenon of injury at the tips and margins of the leaflets sometimes associated with showers or overhead sprinkling, there were very few signs of any leaf injury.

Because of the drought, spraying with a fungicide for the prevention of black spot and powdery mildew was practiced only once every 3 weeks, although one might suppose that with such frequent watering it would be necessary to spray at least once each week. However, a close examination of the foliage showed that the fungicide used, copper oxychloride sulfate (trade name COCS), adhered so well that its blue-green color could be detected readily despite the many sprinklings.

This coloring of the fungicide on the foliage, while obvious to the trained eye, was not conspicuous, not nearly so much so the old Bordeaux mixture or even the Tribasic Copper Sulfate dust mixtures which I have used for some years. Furthermore, the injury to foliage ascribed to various copper fungicides was conspicuous by its absence. Having witnessed a great deal of spray injury in home gardens this year as well as in many years previously, I was surprised to see such a large garden with almost no spray injury.

Since there is experimental evidence to show that powdery mildews, including the rose powdery mildew, can be controlled by simply spraying with water (C. E. Yarwood, Phytopathology 29: 288-290, 1939), there is a likelihood that the frequent sprinklings practiced here had as much to do with control of powdery mildew as the fungicidal sprays, and perhaps more. Copper compounds are not supposed to be particularly effective as mildew controllers.

The seemingly extraordinary effectiveness of COCS in the control of black spot in such a large garden with an insignificant amount of toxicity, is in contrast to results from experimental applications of this material alongside of many others which Massey reported in the American Rose Annual for 1955: 62-91, 1955. In 1950 he used this as a dust containing 3% metallic copper, and while he ranked it high in the control of black spot, he noted that it produced a white residue and burnt the foliage. In combination with sulfur and used as a spray it also ranked fairly high in the control of black spot but burnt the leaves severely. In 1951

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[1] Published with the approval of the Director of the Agricultural Experiment Station.

he again used it as a dust which he ranked lower in the control of black spot than in 1950 and noted "some injury" to the foliage. He also used it as a spray at the rate of 1 pound to 100 gallons and found that it ranked quite low in the control of black spot, 14th out of 20 rankings, and produced injury. The marked discrepancies between Massey's findings and those reported here can at least in part be accounted for by differences in climatic conditions. It is also important to note that with the many fungicides he used, the experimental plots had to be relatively small and perhaps insignificant in size in comparison with the large garden here reported.

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AERIAL INFECTION OF CHAMAECYPARIS BY PHYTOPHTHORA LATERALIS[1]

E. J. Trione and L. F. Roth[2]

Summary

Root rot of Chamaecyparis lawsoniana caused by Phytophthora lateralis has increased greatly along the southwest coast of Oregon in recent years and is now epiphytotic. In the summer of 1954, aerial infections caused by Phytophthora were found on the foliage, branches and main stems of Chamaecyparis. Infections have continued to occur in subsequent seasons, especially in the southern part of the commercial cedar range. Foliage infections are usually localized at the outset, beginning at the tips of branches near the ground, often on the west side of the tree. More and more foliage becomes involved until the entire crown[3] may be destroyed. Main stem cankers are common but difficult to detect and usually are located through the associated discolored foliage. Aerial infections result from detached sporangia and probably also from zoospores carried to the foliage by moisture-laden air or splashing rain. Conditions are favorable for foliar infection during winter and most of the fall and spring months but not during the mild dry summer.

INTRODUCTION

A serious root rot of Chamaecyparis caused by Phytophthora lateralis Tucker & Milbrath, occurs in the Pacific Northwest (3-7). This root disease has intensified and become widely established in native Chamaecyparis in southwestern Oregon (4). The known hosts of Phytophthora lateralis are in the genus Chamaecyparis. Port Orford cedar or Lawson cypress, Chamaecyparis lawsoniana (Murr.) Parl, especially is damaged.

In the summer of 1954, Phytophthora lateralis was isolated from diseased foliage and stem cankers of Port Orford cedar. Such aerial infections were common in the southern part of the native cedar range and have continued to occur there in subsequent seasons. For 18 years prior to the discovery of the above-ground infections reported here, the disease was known only as a root rot. Since the air-borne stage in the disease cycle will complicate control, the aerial aspect of the problem is presented here in some detail.

SYMPTOMS

Symptoms of aerial infection caused by Phytophthora lateralis are readily distinguished from root rot symptoms. The entire crown of a cedar having root rot wilts, discolors and dies uniformly whereas death resulting from foliage infections is progressive. Several years may be required for complete destruction of an infected crown.

Individual branch infections may be scattered through the tree but most often they occur on one side, usually on low hanging branches near the ground. The diseased area increases in size spreading from the lower branches upward and laterally in an irregular triangle (Fig. 1). The average observed yearly upward spread during the period 1954-56 was from 4 to 6 feet although an annual extension of 20 feet was observed in one instance. Infections old enough to appear triangular have a group of dead defoliated branches near the base. Above and to the sides there occur successive zones of symptom expression. The innermost consists of dead foliage discolored a dull dark brown. The middle zone contains bright newly killed but dry foliage rust to brown in color. Foliage of the outer zone is dying but remains moist and pliable with a color range from bronze through grayish green to a water-soaked

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[1] This investigation has been supported primarily by Oregon Forest severance tax funds. Parts will be published in greater detail in the PhD thesis of the first author at Oregon State College.

[2] Respectively Graduate Research Assistant and Associate Professor, Department of Botany and Plant Pathology and Oregon State College, Forest Experiment Station.

[3] The term "crown" as used in this paper refers to the part of the tree bearing the foliage rather than to the root crown.

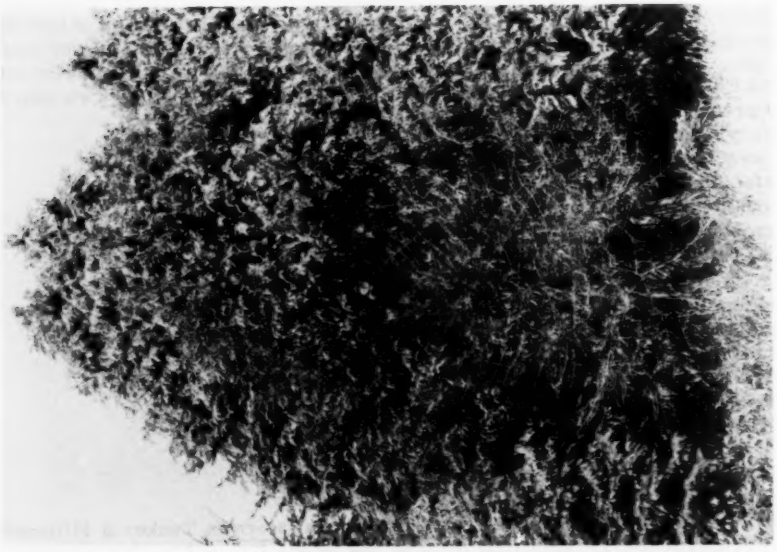

FIGURE 1. Three stages of cedar foliage infection illustrating progressive spread of Phytopathora into the crown: A -- Early infection evident only as discolored foliage at ground level. B -- Older infection with lowest limbs defoliated and surrounding foliage discolored. C -- Older infection with damage extending well into crown.

FIGURE 2. Sporangiophores and sporangia on newly infected cedar foliage in dilute mineral solution.

B -- Older infection with lowest limbs defoliated and surrounding foliage discolored. C -- Older infection with damage extending well into crown.

green. Width and continuity of the zones is determined by crown density and exposure, by climatic conditions, and probably by other factors.

Diseased areas enlarge by secondary infections from sporangia and by mycelial extension from established infections. Under ideal conditions the first symptoms following infection from sporangia and zoospores may develop within 3 days after the spores come into contact with the foliage. As the infection progresses, the leaves farther from the growing point are invaded in succession. At first they are water-soaked, then light grayish-green, later becoming a darker grayish-green. With drying, the color charges to bronze and finally a light brown typical of the dead foliage. Penetration by mycelium from established infections back into the crown results in a blighted appearance when many small twigs and branches are involved. When larger branches and main stems are invaded, cankers form. The cankers are difficult to detect on dry stems and are conspicuous only on fast-growing smooth-barked stems where the cankered area becomes slightly depressed and darker brown than the surrounding tissue. When the stems are wet, the cankers appear a deep chocolate brown and are easily seen. Limits of the cankers in the inner bark are conspicuous, the cinnamon brown infected tissues contrasting sharply with the pinkish-white healthy bark. Old cankers may be easily located by color changes of the associated dying foliage. Occasionally branches striking the ground may become infected directly from the soil resulting in canker formation around the point of contact.

EPIPHYTOLOGY

Trees with aerial infections frequently are found near trees having root rot. Thus, in much of the epiphytotic area aerial infection appears to be associated with infested soil. Foliage infection often begins where low hanging foliage brushes against infested soil during periods of wet windy weather and trees lacking foliage near the ground may escape aerial infection unless inoculum is carried to them from diseased neighboring trees. Spread through the lower branches and to adjacent trees with interlacing branches progresses as weather conditions are suitable for sporangial production. The prolonged growth of Port Orford cedar into fall or early winter, along with the lack of protective bud scales, maintains the branch tips in a susceptible condition over long periods. Water droplets bearing the sporangia and zoospores accumulate at these pendant branch tips.

Spread within the crown from established infections occurs also by mycelial extension back into the twigs and branches. If initial infection occurs on a lateral branchlet, growth from the branchlet into the branch usually results in death of the branch distal to the point of branchlet attachment.

Spread by mycelial growth within a branch is restricted by reduction of moisture in the infected tissues following death of the foliage. This influence appears especially limiting during the summer months.

Aerial spread is clearly influenced by climatic conditions. Preliminary experiments show that sporangia of Phytophthora lateralis form externally on the newly infected foliage only in the presence of free water (Fig. 2). The time required for sporangial development is largely determined by temperature. This observation is supported by experiments in which traces of sporangial formation appeared on infected excised branches in mineral solution (2) after 12 hours at temperatures of 10°, 15°, and 20° C (Table 1). After 36 hours abundant well-formed sporangia developed at the optimum temperature (15° C). Sporangial production was moderate at 10° and 20°, which appear to lie near the minimum and maximum temperatures, respectively, allowing sporangial formation. Sporangial production is most abundant near the tips of branchlets.

Foliage infection also is influenced by temperature. In laboratory experiments employing excised Port Orford cedar twigs in mineral solution, infection occurred within the temperature range of sporangial formation. At the more favorable temperatures (10° to 20° C), infection occurred within 6 days (Table 2). Longer periods were required at temperatures lower than 10° C. For example, after 10 days at 3° only one of the ten branches at that temperature became infected. At 25° infection started early (4 days) but failed even after 12 days to reach the level of infection occurring at temperatures of 10° to 20°. No infection occurred at 30° which is above the maximum for growth.

Table 1. Effect of temperature on sporangial formation of Phytophthora lateralis from infected, surface-sterilized, Port Orford cedar twigs in mineral solution.

Temperature (°C)	Hours following sterilization					
	12	24	36	48	60	84
3	0[a]	0	0	0	0	0
5	0	0	0	0	0	+
10	+	+	++	+++	+++	+++
15	+	+	+++	+++	+++	+++
20	+	+	++	+++	+++	+++
25	0	0	0	0	0	0
30	0	0	0	0	0	0

[a] 0 indicates no sporangial production, + indicates trace, ++ moderate, and +++ abundant.

Table 2. The effect of temperature on infection of excised Port Orford cedar twigs by Phytophthora lateralis.

Temperature (°C)	Days following inoculation					
	2	4	6	8	10	12
3	0[a]	0	0	0	1	1
5	0	0	0	0	4	5
10	0	0	8	10	10	10
15	0	9	10	10	10	10
20	0	9	9	9	9	9
25	0	6	7	8	8	8
30	0	0	0	0	0	0

[a] Number of branchlets infected out of 10 tested at each temperature.

DISCUSSION

Observations to date suggest that the sporangia of Phytophthora lateralis are not air-borne per se but are transported in water droplets. Sporangia rarely develop from infected foliage held in a saturated atmosphere when no free water is present, but abundant sporangial formation occurs when infected foliage is wet. Thus, driving winter rains and hard winds appear important in the spread of the disease.

Minor climatic influences appear to control occurrence of aerial infection. For example, differences occur in its prevalence on the coast between the northern and southern parts of the commercial cedar range, a distance of about 50 miles. Also, aerial infection has not been reported from the climatically different inland valleys where the pathogen is abundant as a root parasite of ornamental cedars. The mild, humid environment on the coast, with an annual precipitation of 65 inches and temperature means of 40° F for January and 60° F for August (1), is ideal for the aerial spread of this pathogen.

Whether the air-borne phase will occur throughout the cedar region, especially away from the immediate marine influence, remains to be seen. Whatever the final distribution of the parasite may be, control will be greatly complicated where aerial infection occurs.

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JUNIPER BLIGHT AND PROGRESS ON ITS CONTROL[1]

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Juniper blight, which is incited by the fungus Phomopsis juniperovora Hahn, has long been recognized as a serious disease of 1- and 2-year-old junipers. Under nursery conditions this fungus is capable of infecting as high as 40 percent of juniper seedlings during a single season. Nurserymen have observed that infected plants, used as understock, seldom unite with the scion. Infected plants which appear compatible may not display disease symptoms for 1 or 2 years following grafting operations. The fungus may also seriously affect the terminal branches of older plants.

Symptoms: -- Diseased plants first turn a light tan color at the stem tip and die. Seedling junipers which are badly infected appear to have been killed by drought. Prolonged periods of rainfall or high humidity, especially in the spring and autumn, favor the spread of the disease. During these periods spores formed in black pin-head size fruiting bodies on the leaves or stems are discharged and distributed by splashing water or insects. The fungus developing from the spores grows into the main stem where it may kill the tissues above and below the point of entrance. On some seedlings, small sunken lesions develop giving the stem a flattened appearance. The causal fungus is capable of overwintering on infected plant parts where it may remain viable for at least 2 years.

Control Experiments: -- The lack of an effective and practical method of controlling juniper blight under nursery conditions stimulated our interest in the problem. Thus, experiments were undertaken in 1955 and repeated in 1956 in an endeavor to determine the effectiveness of various fungicides under conditions of natural inoculations. The study was conducted at the propagating division of the Rhode Island Nurseries, Middletown, Rhode Island, where the disease has been serious.

In the 1955 tests, two commercial beds of 1-year-old seedling junipers were divided into 4 x 4-foot blocks each containing approximately 1500 seedlings. In the 1956 experiments each 4 x 4-foot block contained from 115 to 170 2-year-old seedlings.

Each fungicide was applied as a spray to four randomized plots. Water alone was sprayed on four plots used as controls. The border rows of seedlings in each plot, which could have been covered inadvertently while spraying adjacent plots, were used as guard rows and thus were not included in any of the calculations. Fungicides were used at the following amounts in 10 gallons of water: captan 3.2 oz.; zineb (Dithane Z-78) 3.2 oz.; Kromad (Mallinckrodt Chemical Co.) 2 oz. and 4 oz.; Liquiphene (Vineland Chemical Co.) 0.5 oz.; Malachite Green (Mallinckrodt Chemical Co.) .25 oz.; Merbam (Chipman Chemical Co.) 1 oz.; Morpholine sulfanilate (Mallinckrodt Chemical Co.) 3.2 oz.; dichlone (Phygon XL) 1.6 oz.; sodium sulfanilate 1.6 oz.; and WK-34 (Upjohn Co.) 1.2 oz. In 1955 chemicals were applied with a 3-gallon, hand-operated air-pressure sprayer on July 3, 14, 28, August 25, and September 27, but in 1956 seedlings were sprayed on June 27, July 13, August 3, 27, and September 21, 1956.

At various intervals during the course of the experiment infected plants in each plot were removed and totalled. During these times from 10 to 25 diseased plants were selected at random and examined at the laboratory for the presence of the fungus. The fungus fruiting bodies were detected on most of these specimens.

Results: -- All chemicals tested afforded some control but those which consistently best controlled this disease under the conditions of the experiments in 1955 and 1956 were Kromad, Merbam, and WK-34. The results are recorded in Table 1.

The density of the foliage of the 2-year-old seedlings as compared with 1-year-old may be responsible for the greater number of diseased plants. Dense shade appears to prevent

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[1] Contribution No. 910 of the Rhode Island Agricultural Experiment Station.

FIGURE 1. A view showing nursery beds of 2-year-old juniper plants. The center bed, divided into 4 x 4-foot plots by string, was used in the 1956 tests. The sparseness of seedlings of the two untreated adjacent beds is due to the removal of plants killed by Phomopsis.

Table 1. Effectiveness of certain fungicides for Phomopsis blight control based on the number of 1- and 2-year-old juniper plants exhibiting disease symptoms during the period of July 3 to September 27, 1955 and June 27 to October 10, 1956, respectively.

Fungicide	Ounces in 10 gallons of water	Number of plants treated		Number of plants infected		Percentage of plants infected	
		1955	1956	1955	1956	1955	1956
Kromad	2.0	6000	531	686	42	11.4	7.9
Merbam	1.0	6000	543	655	61	10.9	11.2
WK-34	1.2	6000	560	985	37	16.4	6.6
Control	---	6000	499	1591	201	26.5	40.3
LSD at .05						7.4	4.4

the adequate ventilation and drying needed to help reduce the incidence of disease.

In the 1956 tests, it was noted that even the poorest chemical afforded some control (see Figure 1).

Experiments are now in progress using the aforementioned chemicals to determine their effectiveness under conditions of artificial and natural inoculations.

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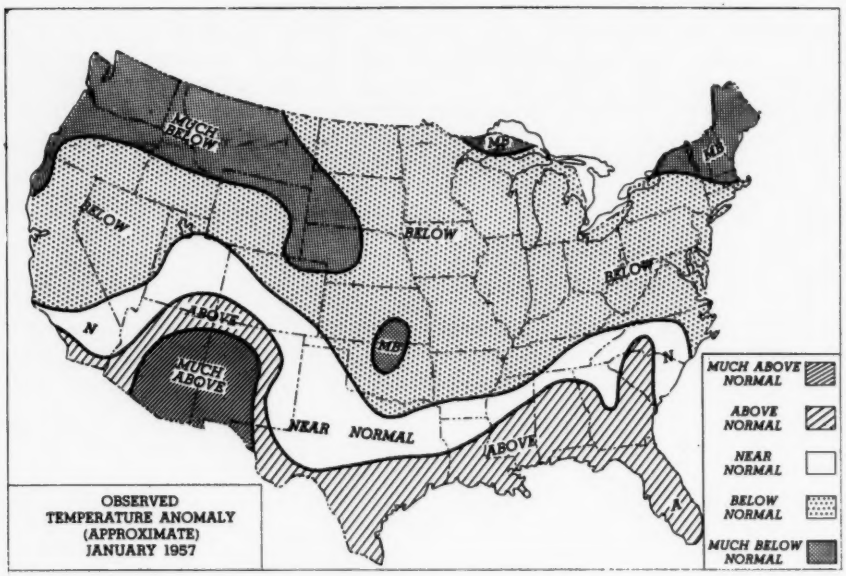
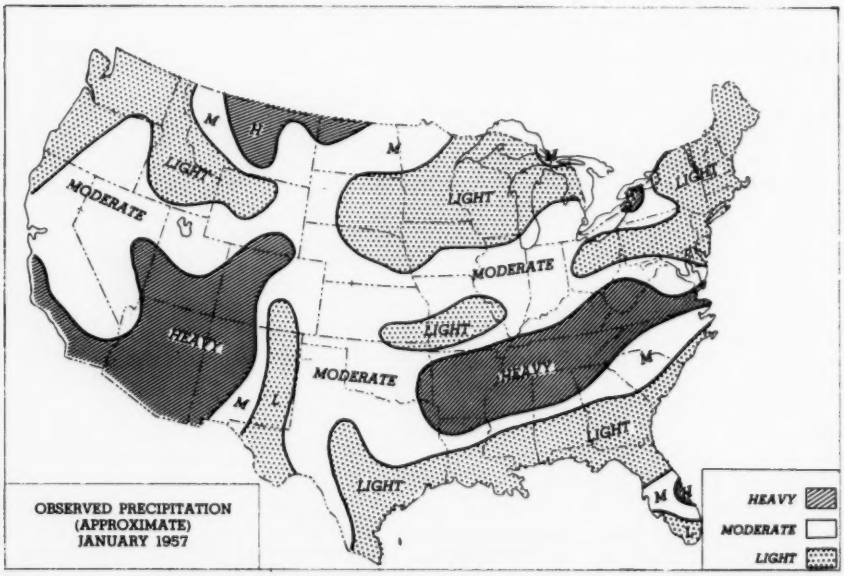
A CORRECTION

REPORTER, Vol. 40, No. 6, June 1956, article by L. E. Williams and J. L. Lockwood "Control of bacterial wilt of cucumber by antibiotic sprays." On page 480, footnote b, the third sentence should read, "Procaine penicillin G, and Neomycin sulfate containing equivalent of 55% neomycin base supplied by Upjohn Company." On page 481, footnote b, the date is July 5.





The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time. Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.